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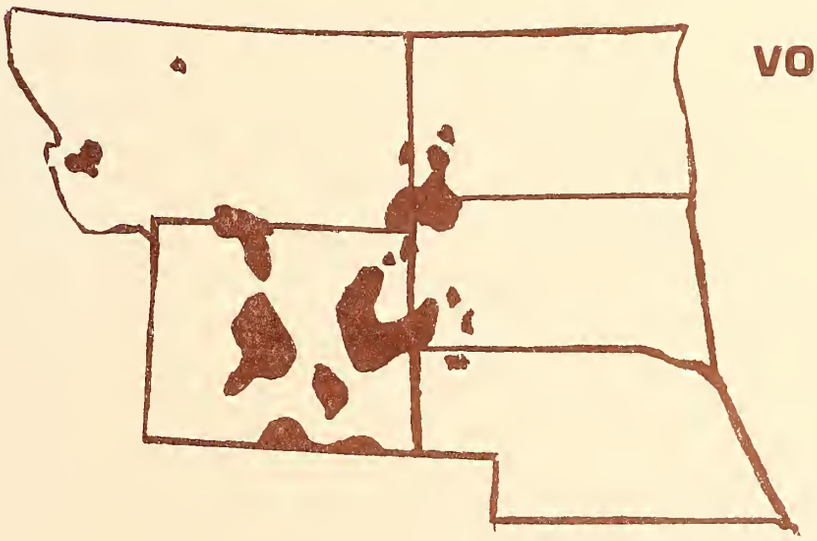

## VOLUME II — APPENDICES

Research Study and Report developed as one element of the Energy Research Project, under a grant from Old West Regional Commission

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# URANIUM RESOURCES OF THE NORTHERN PLAINS

## Volume II - Appendices

by

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1978

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Research study and report were developed as one element of the Energy Research Project under a grant from the Old West Regional Commission, and in conjunction with the Montana Department of Community Affairs and Action for Eastern Montana.

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## APPENDIX A

### Uranium Exploration Activity in Carter County

The material of Appendix A and the associated map (Figure A-1--partial excerpt) were excerpted from Reference (7)--Willard Owens Associates, Inc. Section 208, E.P.A. Grant.

The listed companies have mineral claims and permits allowing them to conduct exploration and related activities in Carter County as shown below:

*(1) Kerr-McGee -- Carter County:

Kerr-McGee filed for lode claim on 8S, 57E, 23B and C. 103 holes drilled in 9S 57E, 23. (*Numbers match locations on Figure A-1)

Exploration has continued into this past summer and except for Exxon this activity is the largest operation in the Alzada area.

(2) Mobil Oil Corporation -- "Fox Hills Project" -- Carter County:

Mobil's exploration activities are within an area of interest located as follows: 3S 62E 7, 8, 9, 15, 16, 17, 18, 20 and 22.

An amendment to the original permit requested more drill holes in 2S 61E 26 (3 holes); 3S 61E 1; 3S 62E 4, 5, 6, 9, 10, 29, 34 and 4S 62E 3, 9, 10.

The Forest Service requirements include provisions that the drill holes be plugged at both above and below the formations for distances of 50 feet when water-bearing formations have been encountered. (Note: Plugging of drill holes into non-water bearing strata may be routinely done by filling the hole with bentonite.)

(3) Mobil Oil Corporation -- Carter County "Ekalaka Project":

Very limited project in Ekalaka Hills area (36 holes).

(4) Mobil Oil Corporation -- Powder River County:

A much more limited program than in the Long Pines area. Drill holes are in the Hell Creek outcrop.

(5) Felmont Oil Corporation -- Carter County "Grassy Butte Project":

Felmont staked claims on 1N 61E 14, 15, 22, 23, 25 and 26. Felmont drilled 125 holes to 100-to-500 foot depths on ½ to 1 mile centers. Holes will "collar" Lebo shale member of Fort Union formation and bottom in the Hell Creek. As many as 173 holes could be drilled; all in 1S 61E and 2S 61E.

(6) Felmont Oil Corporation -- Carter County "Box Elder Creek Prospect":

70 holes drilled in the first phase. Felmont has leases in 1N 61E and would also drill holes in 1N 60E, 2N 61E, and 2N 62E.

(Felmont)--Teton Exploration--Fallon County "Ollie-Carlysle" Project:

30 seismic holes at original depth of 200 feet. 10N 61E 8 and 9.

(7) American Nuclear -- Carter County:

45 holes initially to locate uranium-bearing sandstone in the Inyan Kara geologic sequence at depths greater than 1200 feet.

Holes on claims in Alzada area. 7, 8 and 9S; 56, 57 and 59E. Some holes will be under "TEX" claims.

(8) N.R.G. -- Powder River County:

12 miles southeast of Ashland 25 holes will be drilled to 300 foot depths along Otter Creek. 4S 45E 22, and 27.

(9) Exxon -- Carter County:

213 holes initially on mining property leases and options from Montana Nuclear. 9S 57E, 8S 57E, 8S 58E, 8S 59E, 8S 60E, 9S 60E.

86 additional holes were included. Holes were to be drilled to 1800-foot depths. 151 more holes were added. Because of the depth of mineralization (1800-2000 feet) Exxon will consider using either conventional deep mining or in-place leaching (solution mining). The earliest possible development date is in the mid to late 1980's.

(10) Pioneer Nuclear, Inc. -- Carter County:

2 to 5 holes 800 feet deep in 9S 59E 32 and 33, and additional 7 holes were amended.

CARTER COUNTY -- AREAS OF URANIUM EXPLORATION

Carter County

(1) Kerr McGee
(2) Mobil Oil Corporation
(3) " " "
(4) " " "
(5) Felmont Oil Corporation
(6) " " "
(7) American Nuclear
(8) NRG(Powder River County)
(9) Exxon
(1) Pioneer Nuclear

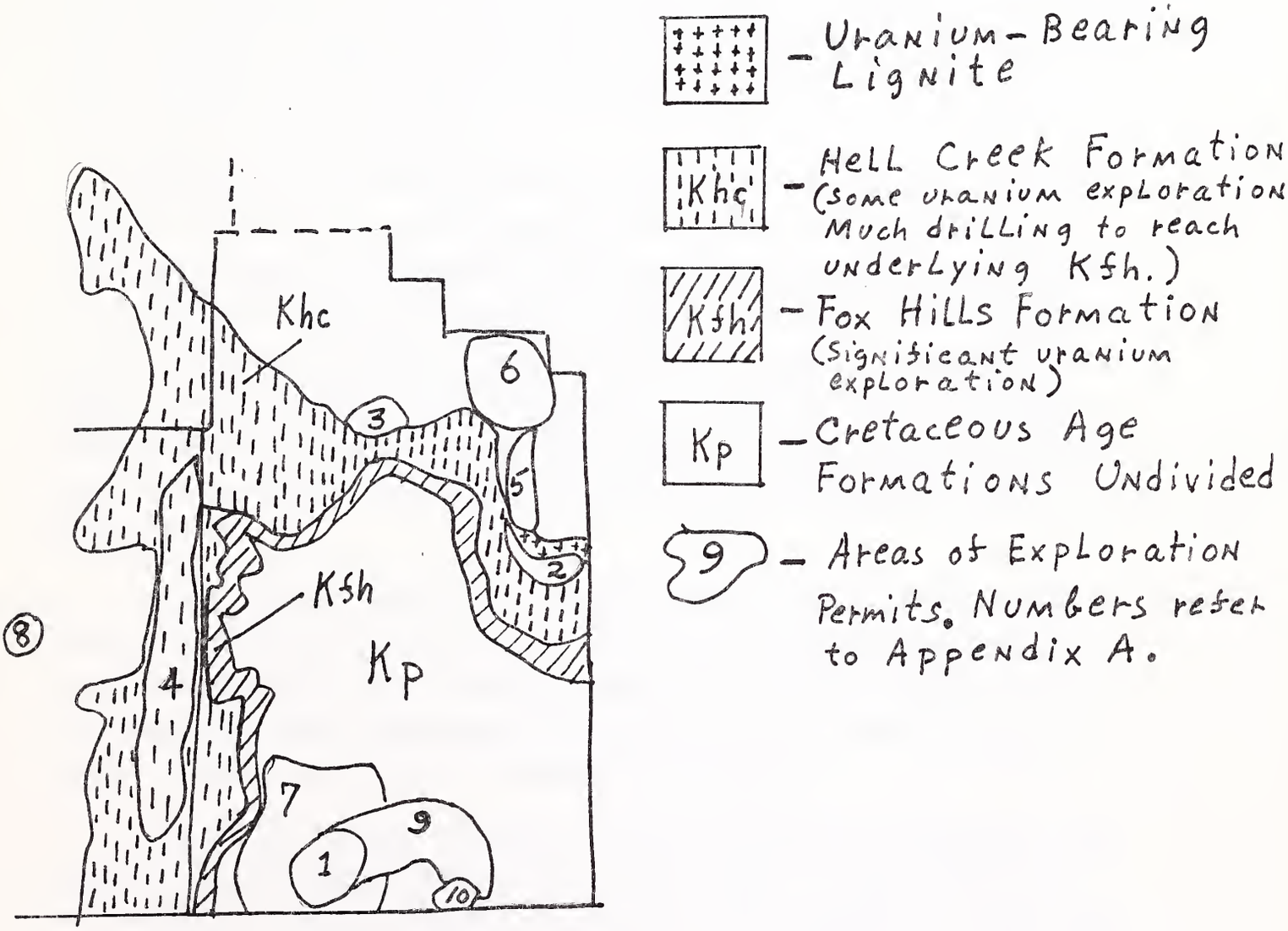


Figure A-1

## APPENDIX B

### Legislation Related to Uranium

*(1) 1872 Mining Law and Subsequent Legislation Relating to Mineral Claims, etc.

Congress enacted the first mining laws in 1865 which consisted of rules and regulations created and adopted by the miners themselves. The 1865 laws were based largely upon California miner's rules. Senator Stewart of Nevada undertook the job of preparing the 1872 mining law which corrected many faults and inadequacies in the 1865 version. Today, federal mining laws are based on this legislation enacted on May 10, 1872 plus thousands of authoritative decisions handed down during the intervening years.

There are two principles basic to the 1872 mining law: (1) the right of the discoverer and operator of a mine to secure and clear title good against the world to their property so long as they fulfill all conditions which are necessary to hold that title; (2) the right of the government, state, or other landlord to rents, royalties, or taxes on the production from the mines. In addition they can demand competent work performance from the lessee. Ownership by the lessee, operator, or mineral discoverer is never obtained except in cases of purchase.

In the western states, including Montana, both principles outlined above apply to mining law. Principle (1) applies to areas open to mineral location on the public lands; principle (2) applies to certain private lands, state-owned lands, and in some cases to mineral-bearing land of the Federal Government in Montana.

Much of the uranium activity in Carter County and throughout the Northern Plains uranium lands is on public lands. Title 43-Sec. 185 of the Code of Federal Regulations states on the subject of lands open to locations:

---

*The material in this section was extracted from Reference (24).

Vacant public surveyed or unsurveyed lands are open to prospecting, and upon discovery of mineral, to location and purchase, as are also lands in national forests in the public-land States, lands entered or patented under the stock-raising homestead law (title to minerals only), land entered under other agricultural laws but not perfected, where prospecting can be done peaceably, and lands within the railroad grants for which patents have not been issued.

For the most part, land in national parks, national monuments, and Indian reservations are not open to prospecting and location.

The mining laws were enacted to encourage and foster the mineral industry in the United States. The law states that after a locator has complied with all rules and regulations pertaining to the acquisition of a mining claim on the public lands and after receipt of patent he receives the land with no reservations, except that the Federal Government may reserve the "Leasing Act Minerals."

The title rests in the patentee absolutely, and after the patent, the mining claim is treated as any other private property.

Mining Claims on National Forests

Generally, mining claims can be made on National Forests, except for lands that have been withdrawn* or otherwise restricted.**

Millsites

Under Montana Law, millsite claims may be located and recorded in the same manner as other claims. Such millsite claims can not exceed five acres. Purpose of a millsite is to provide an auxiliary area for the mine and may be used for a surface plant and mill.

Taxes

In Montana, mineral reserves owned but not developed beneath the surface are not subject to taxation. When a mining claim is patented it becomes subject to taxation. Subsequently, improvements on the mine and value of ore produced are taxed (see Appendix F).

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*Note: i.e. special-use lands such as the Capitol Rock area within Long Pines

**Restrictions prohibit some uses such as building of surface structures, exploratory drilling, etc,on areas such as the rimrock formations of Long Pines.

The extractive minerals industries are allowed depletion provisions in relation to income tax laws. Depletion is allowed when mineral property, oil or gas, "depletes" the source of income so that a deduction is allowed as an incentive to find new ore resources.

Multiple Minerals Development Act of 1954

When uranium was discovered on the Colorado Plateau it became desirable to make provisions that would allow subsequent prospecting for uranium on lands already held under mineral leases. Much of this land in Colorado was already covered by oil and gas leases. Therefore, the Multiple Minerals Development Act was passed in 1954.

Purpose of the Act was to allow mining claims on land already covered by a Federal lease to accommodate the extraction of more than one mineral commodity at the same time.

Multiple Surface Use Act of 1955

This act applies to all unpatented mining claims on public domain in the United States. Essentially, the primary purpose was to avoid mining claims being located for reasons other than legitimate mining operations. Alleged discovery on many of these claims was either sand or stone with the essential design aimed at control of land for various purposes and acquisition of timber, etc.

This law removed common varieties of sand, stone, gravel, pumice, pumicite, cinders, and clay from provisions of the General Mining Law, but does not affect claims on other minerals occurring in association with these common materials.

This law allows the miner to cut or use timber as necessary on his claim under the principles of good forest management, but he must follow the rules and regulations of the administering agency.

Public Law 157

This Act allows entry and location after discovery of a valuable source material such as coal or uranium. In southeastern Montana the lignite beds may come under this Act because uranium is known to occur in these deposits.

Public lands within a coal prospecting permit or lease are not open to location under the Multiple Development Act of 1954.

Along with other requirements necessary to locate a valid mining claim in Montana is the following provision (that would apply if lignite was mined to extract the uranium); the locator is authorized to remove only as much of the lignite as is necessary to recover the valuable source material (e.g. uranium). He does not have rights to all the lignite, nor any of the other Leasing Act minerals (such as oil, gas, etc) which may be associated by chance with the claim.

The so called Leasing Act minerals as basically: oil, gas, coal, phosphate, sodium, potassium and shale. To mine these minerals one must apply to Secretary of the Interior. Since July 23, 1955, Public Law 167 includes sand, gravel, common stone, pumice, cinders, and clay under leasable minerals. Additionally, lignite is considered as a Leasing Act mineral. Source material is defined as any material which the Atomic Energy Commission considers as source material for radioactive energy. The Act allows mining of valuable source material on lands sold by the U.S. Government on which the coal has been reserved to the United States, and the Act also provides for the procedure wherein holders of coal prospecting permits or coal leases could mine valuable source material such as uranium.

(2) Drill-Hole Legislation

(Note: The attached sample exhibit covers plugging of "shot holes" associated with oil and gas development. This legislation does not specify exact techniques for refilling drill holes created by uranium exploration efforts. At present, such uranium exploration holes are being routinely refilled with bentonite and in some instances may be plugged with a concrete plug a few feet below the surface. However, this is done primarily upon the volition of the drilling company. No specific regulations are in force at present, except that on National Forest lands the U.S. Forest Service makes recommendations for filling drill holes and reclaiming the specific vicinity. Specific rules and techniques for refilling uranium exploration drill holes may be implemented in the future.

Drill-Hole Legislation

Senate Bill No. 241. Introduced by E. Smith, Etchart, McCallum, Dover, Kolstad, Mathers, Aber, Olson, Thiessen, Jergeson.

A Bill for an Act entitled: "An Act to extend and further describe the requirements for plugging and reclaiming "shot holes": Establishing additional filing requirements: Providing for enforcement by the Board of Oil and Gas Conservation: Providing for information to be given to the surface user: Establishing additional penalties for failure to comply with those requirements: Amending sections 69-3304 and 69-3308, R.C.M. 1947."

Be it enacted by the Legislature of the State of Montana:

Section 1. Section 69-3304, R.C.M. 1947, is amended to read as follows: "69-3304. Surety bond required -- amount -- filing -- proper plugging and restoration of surface -- certificate of filing. A person, firm or corporation desiring to engage in such geophysical exploration shall also file with the secretary of state a good and sufficient surety bond in the amount of ten thousand dollars ($10,000.00) for a single such geophysical crew or a blanket surety bond in the amount of twenty-five thousand dollars ($25,000.00) for all such geophysical crews operating within the state for such person, firm or corporation, which bond shall indemnify the owners of property within this state against such physical damages to such property as may arise as the result of such geophysical exploration. Unless otherwise agreed as between the owner of the surface and such person, firm, or corporation, it shall be the obligation of such person, firm, or corporation upon completion of exploration to plug all "shot holes" and in such a manner as shall be specified by the Board of Oil and Gas Conservation to contain any water within its native strata by replacing all drill cuttings and filling the hole with bentonite and or cement as required to contain the water and capping the same with an impervious material at least 1 foot in depth, the top of which shall be 4 feet below the surface of the land. The portion of the hole above the cap shall be filled with native material. The person, firm, or corporation shall also restore the surface around the same as near as practicable to

its original condition. The said bond shall remain on file with the secretary of state so long as the exploration is carried on or engaged in, plus an additional 2 years thereafter; provided, however, that the aggregate liability of the surety shall, in no event, exceed the amount of said bond. Upon the filing of such bond, said secretary of state shall issue to the person, firm or corporation a certificate showing that such bond has been filed and showing the name of the designated resident agent within the state for service of process for such person, firm or corporation."

Section 2. There is a new R.C.M. section that reads as follows:

Additional requirements. (1) The county clerk and recorder of the county in which a permit for geophysical activity is issued will immediately forward notice of the issuance of such permit to the Board of Oil and Gas Conservation.

(2) The Board shall notify the county clerk and recorder of the county if the person, firm, or corporation which has obtained a permit is not in compliance with any applicable requirement for engaging in geophysical activity within the state.

(3) If the Board of Oil and Gas Conservation determines that a person, firm, or corporation has violated any provisions of this act, the board shall take necessary action to assure compliance.

(4) Before commencing geophysical activity, the person, firm or corporation shall notify the surface user as to the approximate time schedule of the planned activity and upon request the following information shall also be furnished:

(a) the name and permanent address of the geophysical exploration firm, along with the name and address of the firm's designated agent for the state if different from that of the firm's;

(b) evidence of a valid permit to engage in geophysical exploration;

(c) name and address of the company insuring the geophysical firm;

(d) the number of the bond required in (Section 1 of this act);

(e) a description of the surface areas where the planned geophysical activity will take place;

(f) anticipated need, if any, to obtain water from the surface user during planned geophysical activity.

Section 3. Section 69-3308, R.C.M. 1947, is amended to read as follows:

"69-3308. Failure to comply with act -- misdemeanor. A failure to comply with the terms of this act shall be deemed a misdemeanor and shall be punishable as is elsewhere provided in this code, either by fine or imprisonment, or both. The geophysical permit of any person, firm or corporation convicted of a violation of the plugging requirements of this act shall be revoked and may not be renewed for a period of 2 years after conviction."

## APPENDIX C

### Companies Involved in Uranium Leasing, Mining Claims, and Water Applications

The statistical material for Appendix C was excerpted (with no specific updating effort) from the bulletin, "Energy Companies Active in Montana (February 1975)" published by: Northern Plains Resource Council -- Reference (27). It should be noted that this data was accumulated as of *1975; during the ensuing two years some changes have undoubtedly occurred in the leasing locations, acreages, etc. However, this particular grouping of statistics in relation to uranium activity was judged as being of such specific and primary value to the Uranium Report that it has been included herein even though no up-dating was available.

At point-in-time reference (1975), a number of companies may have been working to assemble "coal-water packages" and other companies were seeking either water or coal resources in Montana. These efforts have continued through the intervening period and into 1978. Available data indicates that there was some interest in uranium development in association with water usage on the order of 50,000 (a.f.) acre/feet per year which could be interpreted as a "package" for uranium-enrichment facilities. Such an enrichment plant that was proposed by Bechtel Corporation in North Dakota would have required 2500 (MW) megawatts of electrical power, and additionally the necessary amounts of water for operation.

A listing of companies with uranium-water holding includes the following:

#### I. Uranium-Water Holdings (1975)

EXXON

Uranium: Prospecting in Silver Bow and Carter Counties

Water: 50,000 a.f. - Bureau of Reclamation option ($25,000/year)- Yellowtail Dam (12/14/67)

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* The Uranium Report generally contains two types of "dated" material: (1) historical importance; (2) statistical importance. Data in the latter category has been reviewed and up-dated to the extent possible within time considerations, etc.

KERR-McGEE

Uranium: 24,180 acres - private mining leases - Carter County
3,204 acres - private mining leases - Dawson County
27,384

64, 290 acres - mining claims - Carter County

Prospecting activity: Carter County

Water: 50,000 a.f. - Bureau of Reclamation option purchased ($25,0000/year) - Yellowtail Dam (11/9/67)

MOBIL OIL

Uranium: 8,460 acres - private mining leases - Carter County

24,800 acres - mining claims - Carter County

Prospecting activity: Carter, Wibaux, Fallon, Dawson, Musselshell, Yellowstone, Garfield, Golden Valley, Petroleum. Judith Basin, Fergus, and Powder River counties; For coal in Wibaux, Fallon, Dawson, Richland, McCone, Rosebud, and Powder River Counties.

Water: 50,000 a.f. - Bureau of Reclamation application - Fort Peck (11/10/72)

II. Uranium Activity (1975)

AMERICAN NUCLEAR

Uranium: Prospecting in Carter County

FELMONT OIL CO.

Uranium: 35,384 acres - private mining leases - Carter County

10, 780 acres - mining claims - Carter County

Prospecting activity: Carter County

FRONTIER RESOURCES

Uranium: 7,680 acres - mining leases - Carter County

INVICTA CORPORATION

Uranium: 11,240 acres - private mining leases - Carter County

KAOBEN INC.

Uranium: 1,040 acres - mining claims - Garfield County

MONTANA NUCLEAR CORP.

Uranium: 5,520 acres - private mining leases - Carter County

17,965 acres - mining claims - Carter County

Prospecting activity - Carter County

## TETON EXPLORATION

Uranium: Prospecting activity: Fallon County

## WESTERN NUCLEAR

Uranium: Prospecting activity: Carbon County

## MISCELLANEOUS

Uranium: 25,660 acres - mining claims - Carter County. The following companies are involved: Bell & Walker, Bug Tussle, Central Resources, Finger Butte Claims, Foster, John McQuire, Pilster, South Side.

## APPENDIX D

### 1872 Mining Law and Some Effects on Public Lands

The Red Desert of Wyoming essentially lies within the Uranium Report's definition of "uranium lands of the Northern Plains." Uranium topics relating to the Red Desert are discussed here because they provide important additional insight into typical and potential problem areas existing between users of the 1872 Mining Law and those environmental and regulatory agencies that must deal with its (the Law's) implementation.

As stated elsewhere herein, the material of this Uranium Report does not represent an attempt to either interpret or offer suggested revisions to the 1872 Mining Law. This discussion of the Red Desert offers a sample view of potential problems on the public lands.

The General Mining Law of 1872, in effect, gives agencies such as the Bureau of Land Management a reduced authority over the exploration and development of uranium in areas exemplified by the Red Desert of Wyoming (28). (This statement represents opinions of course, and voices only one viewpoint as it appears in the researched source listed above.)

Conversely, certain BLM officials who manage the Red Desert region indicate that they can and do place restrictions on exploratory drilling for uranium and other materials. For example, they can choose routes for the temporary access roads, select sites for drilling pads, and halt drilling in areas where elk are actively calving. It is further stated in the surveyed material (28) that exploratory drilling activities usually cause little ecological damage.

However, because 25 to 30 new wells (oil and gas) are being drilled in the Rawlins, Wyoming portion of the Red Desert each year, the cumulative effect must be considered. One observer stated, ".... there are so many short roads they're picking the area (Red Desert; specific local sites) apart." (28)

The Federal Land Policy and Management Act of 1976 (known as the Organic Act) gave the BLM increased responsibility and authority and corrected conflicting and antiquated legislation, but it did not modify the General Mining Law of 1872. (28)

As stated above, the General Mining Law of 1872 gives federal agencies such as the BLM what may be insufficient authority (according to some researched views) over exploration and development of uranium on public lands. Four uranium mines are being actively operated on the Red Desert and more are in the planning or development stage. (28) Recently, the State of Wyoming rejected the application (MEC) for one of these mines. (14)

An application from Union 76's Mineral Exploration Company (MEC) to mine and mill uranium ore in the Red Desert northwest of Rawlins was rejected (July 1977) by the Wyoming Department of Environmental Quality. This is the first outright rejection of a mining application in the Department's four-year history. The two major reasons for the rejection were stated as follows: (1) the failure to demonstrate reclamation of Battle Flats to a use equal to the highest previous use, and (2) final contours of the mining operation exceeded the average of the natural slopes. The underlying problems were accentuated by an ironic twist when MEC's uranium exploration efforts uncovered an 11,000 acre-feet-per-year flow of good ground water in the middle of the Red Desert. A proposed plan to flood the water onto Battle Springs Flat where it would have drowned the greasewood-dominated vegetative cover was deemed unacceptable by Wyoming environmental and regulatory officials. Thus the rejection decision, illustrated that environmental values can outweigh mineral values even within a remote desert area. MEC had the option to either appeal the rejection decision to the Environmental Quality Council or refile an amended mine and milling application. Recent data reveals that MEC has refiled an amended mine and milling application. (14)

In other areas of the Red Desert, some Wyoming wildlife officials question whether elk herds may be driven out of native haunts by increased drilling and mining activities. However, in the past few years, mineral companies have been cooperating to reduce the effects of their

activites on big game animals, but at least one wildlife official feels that the 1872 Mining Law falls short of being completely adequate in that it does not afford sufficient power to effectively protect the elk calving grounds in the Red Desert region. (28)

President Carter's recommendations for mining of both coal and hardrock minerals include measures to further assure that the Department of Interior does not lease any new tracts until it is apparent that the environmental impact of mining would be acceptable and that the Federal Government will receive fair market value for the lease. (14)

If the suggested mining reforms on coal are approved by Congress, the Federal Government will also have the authority to apply the new leasing procedures to minerals such as uranium.

Under terms of the currently in-force Mining Law of 1872 anyone can move to acquire exclusive mining rights on public lands by filing a notice of claim in the local county courthouse. According to the President's Council on Environmental Quality (CEQ), the Federal Government can't refuse to allow mining of the claim and lacks clearly-defined authority to establish environmental standards designed to protect public lands. (14) (In regard to the above general views, the U.S. Forest Service indicates that the potential user of Forest Service lands must provide a plan of operation which is subject to Forest Service approval prior to actual on-land activities.)

## APPENDIX E

### Initial Goals and Current Developments

Viewed on a long-range basis, it is apparent that development of uranium resources and nuclear energy will be at least a part of our energy-production efforts for a great many years into the future. There is no question that nuclear power will continue to have many specialized applications, but many researchers do question whether nuclear energy will play a future role in production of electricity as great as that promised by fossil-fueled plants, solar, wind, etc.

Many of the doubts concerning the continued expansion of nuclear energy have been compiled in the following list which was excerpted and revised from the "analysis" editorial appearing in U.S. News and World Report (24). Under the "Initial Goals" heading, material from other sources as well as general background knowledge has been added as a counter-balance to the "Current Developments" column.

| Initial Goals | Current Developments |
|---|---|
| In the 1950's and 1960's the "peaceful atom" was hailed as an energy-panacea for mankind's future. | Today, atomic power is itself looking for answers to its somewhat clouded future. |
| Nuclear power is providing 9 to 10 percent of current United States Electricity production. | Yet, the next decade's nuclear prospects hinge on settlement of several key questions -- economic, political, legal, and technical. |
| A host of technically-trained and industrially-oriented experts see nuclear power as the primary means that could be used to close the "energy gap" of the next decade or so. | Among the general population a worldwide anti-nuclear movement is mounting a new wave of demonstrations and "teach-ins" regarding the hazards of nuclear power. |

| Initial Goals | Current Developments |
| --- | --- |
| The "breeder" reactors will produce more fuel than they consume. Research and development on breeders could lead on into the fusion process which promises unlimited production of electricity. | Yet, there is little hope that President Carter will soon ease his opposition to the installation of fast-breeder reactors (which may increase both the availability and misuse of plutonium as well as waste disposal problems.) |
| Safeguards and security have been tightened around United States nuclear installations. | The U.S. Government admits to having lost enough plutonium and enriched uranium to build a large number of nuclear weapons. |
| It would be assumed that after the past 27 years of nuclear development, some definite waste disposal plans and techniques would be firmly established. | However, there still is no firm technique for disposing of high-radioactive waste, a source of uneasiness for both the general public and the utility corporations. |
| To meet President Carter's goals for increased nuclear power by the year 2000, total orders for 150 nuclear power plants must be placed in the next 15 years. | Orders for nuclear reactors have decreased. Utilities are finding it difficult to get stockholder support for nuclear power plants because they require 8 to 10 years to reach the operational stage. Coal-fired plants can be built and put on-line within half that time, thus saving as much as 100 million dollars per year on interest payments alone. |

| Initial Goals | Current Developments |
| --- | --- |
| During the reactor boom of the early 1970's, General Electric and Westinghouse, in a four-year period, sold a total of nearly 70 nuclear plants. | Tightening export rules and growing international competition are adversely affecting attempts to sell American-made reactors abroad. Also, sales are down in this country. From 1974 on, there were 27 orders for new nuclear units, but 32 previous orders were canceled. |
| Although specific demands for energy are on the increase in the United States, the demand has decreased generally and overall. | Manufacturers of nuclear plants are faced with an oversupply of generating capacity. Construction programs were based on growth estimates of the early 1970's when demand for electricity was rising at 7 percent per year. This growth was slashed by the Arab oil embargo and a recession that reduced growth of energy markets to 2 percent during 1974 and 1975. Matching construction to growth needs, utilities postponed and canceled orders for power plants of all types -- nuclear, oil, and coal. Since then, despite a sharp increase in consumer demand, there have been few new orders for nuclear plants. |

| Initial Goals | Current Developments |
| --- | --- |
| Development of nuclear energy was underwritten and advanced under a federal law (Price-Anderson Act) that put a top limit of $560 million on liability of power companies in the event of a nuclear accident. | A Charlottesville, Va. judge ruled against the federal law (Price-Anderson Act) that limits how much money can be claimed in damages as a result of a nuclear accident. This law protects utilities from having to pay more in damages than the $560 million maximum, of which sum $450 million would be paid by taxpayers. |
| The splitting of the energy-production load between nuclear and coal may be a neck-to-neck race. | Utilities see new and stricter rules for coal-burning plants as a possible incentive for construction of new nuclear plants. However, nuclear developers do not see a surge of orders in the immediate future. One company executive is betting that half of the new power plant orders between now and year 2000 will be for coal and half for nuclear. |
| Can nuclear energy produce up to the expectations held for it in the 1950's? | According to estimates of the Energy Research and Development Administration, by year 2000 atomic energy will be producing 40 percent of the Nation's electricity (this means an average increase of 15% for each of the two decades of the 1980's and 1990's). |

| Initial Goals | Current Developments |
| --- | --- |
| Breeder reactors have been regarded in some quarters as the next major step toward energy independence. | Although President Carter is attempting (1977) to stop the 2.1 billion dollar Clinch River breeder demonstration project, he is requesting 450 million dollars for other U.S. breeder research. |
| According to industry spokesmen, nuclear plants can be built in 5 years. Obviously, faster construction may be required over current capabilities if the optimistic goals for nuclear production of electricity are to be met. | To accomplish this shorter time span, years of diligent work must be accomplished to untangle priorities, streamline decision-making, and improve all phases of nuclear power production so as to clear up uncertainties. |

Commenting briefly on the above "Initial Goals" and "Current Developments" chart, and using middle-of-the-road views, one can forsee possible solutions.

Nuclear safeguards against leakage, accidents, and terrorists activities will by necessity become increasingly strict; nuclear energy will eventually seek and assume its own specific types and level of usefulness alongside other forms of energy production; waste disposal problems will receive new attention and a greater push will be initiated toward a certain and safe means of attaining a near 100 percent reliable technique of disposal for high-level radioactive wastes.

APPENDIX F

## Part 1: Montana Metalliferous Taxation Relative to Uranium

This portion of Appendix F (Part 1) is a generalized review of its metal mine laws, but not necessarily complete as to each and every recent amendment. Those requiring complete details and amendments should refer to the reference codes. Revised codes of Montana 1947, Title 84 and Volume 5, Part 2, 1977 Cumulative Supplement. (Available in local libraries.)

### License Tax -- Metalliferous Mines

The tax provided by this chapter is not a property tax -- on metals, minerals, or mine products -- but an occupational license tax, i.e. upon the business of producing metals or precious stones, based upon annual production.

Every person engaged in working or operating any metal mine in Montana is subject to this tax. He shall pay to the State Department of Revenue for such annual license the taxes as prescribed. Nothing contained in the Act shall be construed as requiring mine laborers and employees to pay the license tax. Furthermore, the following activities shall not be deemed as the engaging in or carrying on of the business of working or operating a mine or mining property (thus, the license tax does not apply): (1) discovery work required for prospecting or locating any mining claim; (2) any kind of assessment work, and (3) work required in the obtaining of title to mining property from the United States, or required by the laws of the United States or of this State (Montana) in order to hold possessory title to any mining claims.

### Gross Value of Products; How Determined

The total "gross value of product" means the market value of all merchantable metals, as extracted each year from any mine or mining property in Montana. The amount of the license tax collected shall be based upon the market value of the gross product in Montana.

Amount of Tax

The annual license tax to be paid shall be one dollar, together with an additional sum based on the gross value of the product produced during the calendar year, at the following rates:

Table F-1

| Gross Value of Product | Rate of Tax |
|---|---|
| First $100,000 | 0.15 % |
| $100,000 to $250,000 | 0.575 % of the increment |
| $250,000 to $400,000 | 0.86 % of the increment |
| $400,000 to $500,000 | 1.15 % of the increment |
| over $500,000 | 1.438 % of the increment |

Statement of Gross Value of Product

Not later than April 15 of each year every person conducting a mining operation in Montana must submit to the State Department of Revenue a statement describing the gross value of product from mines and mining properties operated by the person during the preceding calendar year. This statement shall show the following data: (1) name and location of smelter, mill, or processing works to which such ore has been shipped or sold during the period covered by the statement and such other data as required by the State Department of Revenue.

Computation and Notice of Tax:

The State Department of Revenue shall examine the statement and compute and assess the license tax to be paid by the mine person, and mailed not later than June 1, indicating the amount of taxes due.

If any person has sold any of the mine's product, the gross value of product will be based on the quotations of the price of such mine's product as listed in the Engineering and Mining Journal of New York City or some such standard publication. Lacking such a quotation, the State Department of Revenue will fix the value of the gross product.

Delinquent Taxes

Taxes are delinquent if not paid by the last day of June following the assessment date. The penalty for delinquent taxes is 10 percent which shall be added thereto; and the whole amount of the license tax, with penalty added, shall bear interest at the rate of 1 percent per month, or fraction thereof, from the date of becoming delinquent until paid.

Procedure in Case of Failure to File Statement

In essence, if any person (operating a mine, etc) fails to file the Statement of Gross Value then the State Department of Revenue will attempt through whatever means are available to determine the gross value and will then assess the person for that amount.

False or Erroneous Statements

Should any statement or gross value be suspected of being erroneous, then the State Department of Revenue may require that the person, or company officers, appear before the Department to testify. If the person or officers refuse to allow Department personnel to inspect the company books or records, then the person or officers can be deemed guilty of a misdemeanor, with conviction carrying a fine of up to $1000 or 6 months in jail, or both.

If books and records are determined to be false, the Department Director shall change the records to show correct gross value amount and shall reassess the amount due from the person and may add a penalty not exceeding 50 percent of the base amount due.

Interest on tax due is assessed at the rate of 1 percent per month or fraction thereof.

Hearing on Determination of Value of Gross Product

Every person who feels aggrieved by Department determination and assessment of his license tax may file a petition for a hearing wherein he states the grounds and reasons as to why the amounts of the gross value of product or license tax should be changed.

## Part 2: Montana Metalliferous Taxation Relative to Uranium

The following material (Part 2) for Appendix F was excerpted from Reference (29). Discussion herein of "mineral" or "coal" can be inferred as applying also, at least in a taxation sense, to uranium. Uranium is classified under metalliferous ores, along with minerals, for purposes of taxation in Montana.

Four mineral taxes are described herein and evaluated: (1) ad valorem; (2) severance; (3) gross production; and (4) net production.

Because mine construction or actual on-scene development can take several years (normally around three years), any tax based on the output of the mine makes no contribution to government revenues until after the need for new services has arisen. Many local governments in various western states face this front-end financing problem. None of the taxes discussed here, with the possible exception of the ad valorem tax, solves this problem satisfactorily. Some of the western "energy" states, including Montana, have enacted special programs to ease this problem, but the programs are so new that their impact cannot yet be properly evaluated.

Although the new programs may in some respects underestimate the scope of the front-end problem, most major mineral-producing States do have a special tax system for mines and mineral production.

During the several-year period that a new mine is being made ready for operation, the so-called "front-end" load problem may develop. Many Northern Plains states set limits on local millages and prohibit bonding for operating expenditures. Therefore, the immediate need for new services may outstrip the locality's ability to finance them until after the construction and setting-up phase of a new mineral mine or plant reaches the full production stage.

If no way is found to balance the revenues and expenditures made necessary by the new industry, then permanent residents of the community may see a significant increase in their tax bill while the mine is being developed.

## The Ad Valorem Property Tax

Today, several of the mineral-producting States rely upon ad valorem taxes as their principal means of taxing mines. Although it produced sufficient revenue for most local communities, the ad valorem tax had critics who focused their comments on social justice, consistency with national economic goals, and ease of administration.

In earlier days, mines were treated the same as all other industries and taxed by the ad valorem property tax, with no special tax on either the physical product or the value of the mine being levied. Mine taxes depended only on assessed value and the local millage rate, and they were levied whether the mineral deposit was being worked or not.

Administrative difficulties were probably responsible for reduced usage of the ad valorem tax. Estimating the value of a mineral deposit and assessment is difficult. Factors adding to this difficulty included the following: mineral deposit is hidden underground; prices are volatile; unpredictability of future extraction costs; comparative sales data lacking; detailed data on size and richness of the deposit may be inaccessible to local assessors; and the amount of ore extractable from the mine depends at least in part on the capital investment in the mine.

The above difficulties encouraged the States to begin using net income or net profit to estimate an assessed value of mineral property.

The ad valorem tax also was criticized for being inconsistent with the national goal of maximizing the use of available resources. This tax comes due whether the property is worked or not; thus a profit-maximizing producer will accelerate his recovery rate on each deposit in order to minimize his total tax bill. Two identical mineral deposits, one of which was mined out within 5 years and the other mined out in 10 years would pay considerably different amounts of taxes. Over the shorter term, of course, fewer taxes would be paid. Such a system encourages short-term development and extraction of the mineral property.

An accelerated depletion of the mineral deposit leads to a drop in the price of the mineral which, in turn, produces two effects. First, usage of the mineral increases. Second, and possibly more important, the

cutoff grade for the ore to be mined is raised, reducing the amount of economically-feasible ore available to extraction by mining. This means that ore of lesser value than the cutoff grade will not be mined. Since large mine start-up costs would be involved, extremely high prices for the mineral would be necessary before it would become economically feasible to re-open the mine. The lower-grade ore left in the ground is not lost, but the economics of mining may prevent commercial use of this ore. Thus, the ad valorem tax would have worked against the country's best interests, which is served by either preserving or by making the best possible use of our national resources.

Under the category of "social justice" two concerns arise in relation to the ad valorem tax: (1) inter-regional tax inequity; and (2) national heritage.

Concerning tax inequity there seems to be no justification for the mine's tax bill to depend on the amount of other development in the area. A single rich mine in a sparsely-populated area might support a major portion of the tax base in the taxing district, and the tax bill could be much greater than if the mine were located in a region with more mining enterprises.

When discussing the national heritage issue some argue that a mineral deposit is a gift of nature to the people and they deserve rent or compensation for the asset. Many feel that a share of the excess profit from a mineral resource should be returned to the people of the State. However, those using this argument actually are simply favoring a higher tax on minerals and are not necessarily arguing against the ad valorem method of taxation.

As with most equity arguments, it is difficult to evaluate the national heritage argument in terms of right or wrong. Decisions regarding it are more properly made through the governmental decision-making process.

Unlike other taxes discussed herein, the ad valorem tax has no problem in matching the revenue flow with the need for services. The front-end load problem is minimized because the mine property has the same value whether the mine is operating or being developed, i.e., assuming proper assessment.

In some States (Minnesota for example) the ad valorem tax worked too well and the State government eventually was forced to place a ceiling on increases in local per capita expenditures. Lacking such a limit in the iron range communities of Minnesota, local government expenditures in that area would have become completely distorted from those in the rest of the State.

## Types of Severance Taxes

Three distinct types of severance tax are discussed herein; (1) the "true" severance tax, (herein referred to as "severence tax") which is levied at a set amount per unit amount of mineral produced; (2) gross production tax, levied on a measure of the dollar value of the product extracted from the mine; (3) net production tax, which is more closely related to a net income tax wherein companies are allowed to deduct some expenses from gross revenues to arrive at a definition of net taxable production.

Today, 29 states have some form of special taxation on minerals. In 10 States the tax is levied in lieu of all other ad valorem taxes; in the other 19 States, some ad valorem taxation is levied at either the State or local level.

Severance taxation existed as early as 1846, in Michigan, the first state to impose a tax other than ad valorem.

The courts treat severance tax as an excise tax paid by producers for the privilege of extracting resources from the soil of the State. Thus, severance taxes are not considered to be property taxes, and are not held to be subject to constitutional restrictions applicable to property taxes such as millage limits and uniformity provisions. In addition, since they are not property taxes, it is not normally considered as double taxation when they are imposed in addition to an ad valorem tax.

### "True"Severance Tax

Under this system of taxation there is no tie to the value of the product being mined and only the number of tons mined per year needs consideration. The severance tax is levied according to a rate schedule based on the amount the mine produces. Thus, administration

of taxation is greatly simplified as compared to need for assessment, etc,under the ad valorem tax.

The severance tax, viewed as to social justice, generally surpasses the ad valorem tax due to the following advantages: (1) severance tax is at the same rate for all areas regardless of relative property tax rates in the vicinity of the mine; (2) severance taxes are based on the ability of the taxee to pay and are due only when the mine is in operation. Ad valorem taxes become due even if the mineral deposit is not being mined.

The severance tax offers no tax incentives for increasing the mine's recovery rate, thus the tax is more nearly in accord with the national goal of maximizing resource use. The rate of extraction remains unchanged with respect to any change in the level of the tax, and there is no way the company can mine out from under the tax, as it can with the ad valorem tax.

It is with regard to revenue adequacy that the severance tax exhibits its greatest deficiency. This tax is based on the physical output of the mine, thus the revenue developed may not cover the need for additional government services associated with the mining project. Especially during the early stages of development it is likely that revenues will be far below those needed to finance the new levels of required services. Thus, we face the front-end load problem.

The construction period for a mine can last for three or more years, thus additional revenue must be made available prior to actual opening of the mine. This need is especially severe in sparsely-populated areas where existing public services will typically be inadequate to serve the new residents. If revenues from the mine are not available until after the need for more local services arise, the local community will suffer in the short term. However, this may be only a temporary problem because shortly after the mine begins full-scale operation the new revenues will begin to exceed service costs.

The question concerning the problem of time lag between beginning of mine construction and flow of revenue is of uppermost importance to local governmental agencies. Attempts to relieve this problem include "piggy back" severance tax by local governments and attempts at returning

funds to the energy-impacted areas.

Only the State of Alabama has specifically allowed the enactment of a "piggy back" severance tax. Another means of channeling funds to local government is through creation of a specific distribution formula. Or State programs of aid to local governments can be modified so that areas impacted by mineral development receive a different allocation of funds. Montana, North Dakota, and Utah have recently enacted legislation aimed at returning funds to the impact areas. Lacking some specific programs or provisions, the costs of a new mine or mining complex to the local community is likely to greatly outweigh its benefits and there will be strong local resistance to its development.

One other problem affecting a severance tax is the fact that such tax fails to adjust automatically to the effect of inflation on local revenue needs. This tax is levied at a fixed dollar amount per ton; thus during a period of inflation the quantity of government services financed by the tax will decrease even though the tax is producing the same dollar amount of revenue. Recognizing this problem, several States have linked the severance tax rates to a price index which allows local government revenue to keep pace with inflation.

In summary, the severance tax is viewed as an improvement over the ad valorem tax when evaluated as to administrative convenience, social justice, and consistency with national economic goals. It is only in the area of revenue adequacy that the severance tax compares unfavorably with the ad valorem tax. The relative revenue-inadequacy and front-end load problem, much worse under this system of tax, requires special provisions as outlined above. Furthermore, because producing revenue is the purpose of all taxes, the severance tax and its implementation poses a serious problem which State legislatures must face.

Gross Production Tax

Under the gross production tax, the dollar value of the product extracted from the mine is taxed. This system of taxation is available to both State and local governments and 17 states who currently use this method.

The gross production tax is nearly identical to the severance tax.

However, because the tax is levied as a percentage of the value of the ore rather than at a fixed amount per ton, there are some important differences. The primary differences relate to the more equitable approach to assessment and to the social justice factors.

A primary advantage to the gross production tax, from the viewpoint of local government, is that tax revenues increase when mineral prices increase, which protects against inflation. However, this responsiveness to price changes could cause problems for governmental agencies during a long period of depressed prices. In some circumstances, the disadvantages of accepting a fluctuating revenue source may outweigh the advantages of having a built-in hedge against inflation.

Some difficulties may arise in computing the mineral's sale price, thus causing the gross production tax to be more difficult as to administration than the severance tax. The problem arises specifically from the fact that there often are no market transactions from which prices can be obtained.

If the administrative problems are adequately handled, the gross production tax is an improvement over the severance tax in terms of social justice. The gross production tax more adequately matches the mining company's tax bill with the company's ability to pay under conditions where mineral deposits are of varying quality and mineral prices are not stable. When gross receipts of the mine serve as the tax base, differences in the quality of the mineral extracted can easily be taken into account and taxed accordingly. Thus a mine producing minerals worth $5 a ton and another producing minerals worth $10 will be taxed differently. Their tax bills will be proportioned to the value of the mineral produced. Also, the sale price of the mineral will be directly reflected in the mine's tax bill.

The gross production tax and the severance tax may affect the cutoff grade of a mine differently. The severance tax is a fixed charge added to each ton of mineral produced. Thus, production of lower-grade minerals may be reduced. Mineral deposits will not be developed where the marginal cost of production and the severance tax are greater than the market price. The gross production tax may allow some mineral production that would be stifled by provisions of the severance

tax. This is true because the gross production tax is a percentage of the sales price rather than a fixed amount per ton, thus a lower tax is provided for lower-quality minerals.

Neither the gross production tax nor the severance tax successfully deal with front-end load problems. Thus, local governments attempting to provide services for new residents during the construction and development phase of mine establishment may find scant assistance from either of these two tax methods. Special provisions modifying the severance tax are detailed elsewhere herein.

Net Production Tax

The net production tax, resembling a net income tax, allows the taxee to deduct some expenses from his gross revenues in order to reach a definition of net taxable production.

Special administrative problems occurring under this system of tax include: (1) officials must check costs claimed as business expenses and must estimate gross income; (2) income tax returns are checked and audited to obtain necessary cost figures, all of which increases the administrative burden.

When judged only as to social justice, the net production tax surpasses all of the other systems of taxation. If designed so that all of the firm's relevant costs are included, then this tax is superior to all other systems. However, the tax is less satisfactory in cases where the firm's deductible costs do not include all relevant costs to the firm.

The net production tax is also an improvement over the others as to consistency with national economic goals, assuming that the tax adequately reflects both income and costs of doing business. Similar to the severance tax it does not interfere with the optimum rate of recovery in the mine and there are no incentives to mine out from under the tax as may occur under the ad valorem tax. Additionally, because the tax levy is a percentage of net income, the net production tax does not encourage the restriction of mine output as do the severance and gross production taxes.

Reduction of the mine's profits is the only effect caused by the net production tax. Under this system of taxation the marginal cost of

mining each ton of mineral ore remains the same as it would be without the tax. Thus, a profit-maximizing firm will mine the same amount under a net production tax as he would if there were no taxes at all.

When mineral production is subjected to greater tax burden than other sectors of the economy, investment in mining decreases and the less-profitable ores will not be developed. The net production tax system avoids these constraints which are inherent in other tax methods.

The net production tax shares inadequacies with the severance and gross prodcution taxes in regard to font-end load problems. The problem may be even worse with the net production tax because a new mine may operate at a loss for the first few years. Also, there will probably be periods during which due to fluctuating market prices, the mine will have little net income, but a full complement of new-resident workers.

A local government attempting to provide expanded services only under the net production tax could face extreme problems.

Because of its inherent weaknesses, use of the net production tax is not advisable at the local level, but is recommended at the State level. Viewed in total perspective, the net production tax has advantages over the other methods of taxation, especially with regard to social justice and compliance with national economic goals.

## Conclusions

No one of the tax methods is clearly superior to the others when all requirements are considered (Table F-1). The severance tax and gross production tax may provide the most acceptable methods of taxing mining activity, with the choice between the two probably resting on a basis of how difficult it is to determine a sales price for the mineral being taxed. If a market price can easily be determined for the minerals coming from each particular mine, the gross production tax offers several advantages over the severance tax. If, however, an appropriate market price is not available, the State may be better off with a severance tax.

Table F-1. Mineral taxation methods ranked as to evaluation criteria

| Type of Tax | Ease of Administration | Social Justice | Consistency with National Economic Goals | Revenue Adequacy |
|---|---|---|---|---|
| Ad Valorem | * | * | * | **** |
| Severance | **** | ** | ** | *** |
| Gross Production | *** | *** | *** | ** |
| Net Production | ** | **** | **** | * |

* = Lowest Rank

## State Programs Designed to Reduce Local Impacts of Mineral Development

During the early phases of mine construction and development the special taxes on minerals typically fail to offset the increased costs of providing local government services for new residents. The local government's expanded services must be financed from the existing tax base, but the value of the new development is not a part of the local tax base during the first few years.

In many communities the benefits of growth outweigh problems associated with a possible short-term imbalance. These fortunate communities may have the necessary excess capacity in their public service systems to serve the new needs, and there may be enough local workers to fill the needs of the development, thus necessitating no in-migration of new residents. In some areas, State and local governments have attracted new developments by exempting new firms from either all or most of its local property taxes for several years. However, it is only where the new growth is relatively small as compared to existing local population that this tax concession strategy will operate successfully.

In view of socioeconomic impacts it is unfortunate that most mineral developments on the Northern Plains occur in regions where small towns are few and far between. Thus, the potential financial benefits of development to the community and the abilities of local governments to successfully cope with increased responsibilities are largely negated. Local residents of such isolated areas sparsely dotted with small towns may face either a decline in quality of local services or an increase in their own taxes. Those in States where statutory limits are imposed on property tax millage rates may simply be forced into accepting a lower-quality in all their community services.

Although many local residents maintain that the situation is unfair and inequitable, no overall answer has been discovered. Of course, local residents may be assessed lower taxes after the mine or other development reaches full production capacity. However, the short-term prospects may continue to be disturbing.

Attempts to resolve the front-end load problem must continue if the Nation's mineral resources are to be developed in a reasonable and socially-acceptable manner. Four of the states that are facing extensive coal development in sparsely-populated areas have already enacted legislation to deal specifically with this problem.

## Montana's Modification of the Coal Severance Tax

The 1975 Montana State Legislature modified the coal severance tax to take account of possible local fiscal imbalances caused by coal development. A Coal Board was established with the power to award impact grants to counties, towns, and school districts on the basis of need, degree of severity of coal development, availability of funds, and the degree of local effort in meeting the needs. The Board has seven members all of whom are appointed by the Governor. Two of the members are required to have expertise in school matters and two others must reside in coal impact areas. It was reported that the Board would have approximately $18.5 million to distribute during the 1975-1976 biennium.

The Legislature also created a special property tax classification for gross proceeds from coal strip mines. This action by itself will produce no revenue prior to the mine's operation. But, a companion measure requires that those constructing a new firm or mine, which will have a major impact on the existing public services, must prepay on request an amount not to exceed three times the estimated property tax due the year the facility is completed. One-fifth of the amount prepaid is then allowed as a credit in each of the first 5 years after the start of production operations.

There is no way at this time to forecast whether the revenues allocated to the Coal Board will meet the needs of Montana's impacted communities, or whether the 3-year prepayment of property taxes provides enough to cover temporary fiscal imbalance of the locality. The property tax prepayment provisions by themselves may solve the front-end financing problem of the taxing districts in which the mine is located. For these communities, the extra revenue is certain and quickly accessible. And, it can be obtained by local action without waiting for the

judgement of the Coal Board or any other State agency regarding need for the funds. Impacts on the local governments outside the immediate vicinity of the mine may not be handled as well. The actions of the Coal Board will determine whether the financial problems these communities face will be treated adequately.

## Summary of Montana State Tax Laws

Montana levies several special taxes on mines and mineral production. There are taxes on coal production, metalliferous mine production, oil and gas production, micaceous mineral production, cement, and gypsum. And there is a tax on the gross product of any type of mining. In addition, since these taxes are not in lieu of the ad valorem taxes, all mines are subject to local property taxes. In 1975 the State received about $14.6 million or about 6.3 percent of State tax revenues from these taxes. Gross receipts are used to measure the value of coal mines. Other types of mines are valued on their net production.

The State levies a general mineral mining tax on all individuals or firms mining, extracting, or producing a mineral from the surface or subsurface of the State. This tax is levied at a rate of $25 plus 0.5 percent of the gross value of the production in excess of $5,000. The revenue from this tax goes to a special State fund. * (84:7007) When the fund reaches $10 million, then interest may be used to rectify environmental damage caused by coal mining. When the fund reaches $100 million, revenue from the tax as well as the interest generated can be used.

Minerals are also taxed through a series of selective license taxes levied on the privilege of mining. These tax rates differ allowing the State to take account of differences in production costs for different types of minerals.

The license fee for mining metals, precious or semiprecious stones, or gems is based on the gross value of the products. The annual fee is $1 plus the gross production levy. Rates for the gross production levy are: first $100,000, 0.15 percent; exceeding $100,000 but not exceeding

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*Material within brackets refers to applicable State Codes.

$250,000, 0.575 percent; exceeding $250,000 but not exceeding $400,000, 0.86 percent; exceeding $400,000 but not exceeding $500,000, 1.15 percent; exceeding $500,000, 1.438 percent. (84:2004)

The State license tax on micaceous minerals such as vermiculite, perlite, kerlite, and masonite is 5 cents per ton. Cement is taxed at 4 cents per 376-pound barrel, or 5 cents per 2,000 pounds of cement plaster, gypsum, or gypsum products. (84:5902; 84:1102; 84:1202)

Every person producing or extracting oil or natural gas in Montana must also pay a tax on the total gross value of all merchantable or marketable petroleum or natural gas produced. Natural gas is taxed at a rate of 2.65 percent of gross value. Oil is taxed at 2.1 percent for the portion of production equal to an average of 450 barrels per well per day and 2.65 percent of that portion of gross value of all production in excess of that amount. (84:2202)

A conservative tax is also levied at rates set by the State Oil and Gas Commission. The rates are 3/8 cent per barrel of oil on leases producing an average of 25 barrels per day or less and 3/4 cent per barrel on production from wells averaging more than 25 barrels per day. For natural gas the rates are 2.5 mills per 10,000 cubic feet of natural gas if marketed for more than 15 cents per 1,000 cubic feet. (60:145) The proceeds from the conservation tax are used to pay the expenses of the Oil and Gas Commission.

Coal mining is also taxed through a license tax. The 1975 Legislature modified the existing coal producer's license tax to take better account of the differences in cost between strip mining and underground mining. They also hoped to stabilize the flow of tax revenues from coal mines to local government through the property tax system and to simplify the structure of the coal taxation system in Montana. To accomplish this they imposed a severance tax with the rate depending on both the heating quality of the coal and the way in which it was mined. The rates are:

| BTU's/lb. | Surface Mine | Underground Mine |
|---|---|---|
| 7,000 or less | 12¢/ton or 20 % of value | 5¢/ton or 3 % of value |
| Between 7,000 & 8,000 | 22¢/ton or 30 % of value | 8¢/ton or 4 % of value |
| Between 8,000 & 9,000 | 34¢/ton or 30 % of value | 10¢/ton or 4 % of value |
| More than 9,000 | 40¢/ton or 30 % of value | 12¢/ton or 4 % of value |

Taxpayers are entitled to exclude 5,000 tons of coal annually from the tax. (84:1314)

Revenue from the coal license taxes is allocated in the following way:

1. The county receives 3 cents per ton or 4 percent of the value of the coal mined in the county, whichever is greater, for years up to 1980. For 1980 and beyond, the rate is 3 cents per ton or 3.5 percent of revenue.

2. Two and one-half percent of toal collections per year until 1979 and 4 percent thereafter are earmarked to the credit of the Alternative Energy Research Development and Demonstration Account.

3. The Local Impact and Education Trust Fund Account receives 27.5 percent of total collections per year, until July 1, 1976 and thereafter 35 percent.

4. For each of the 4 years following the effective date of the Act, 10 percent of total collections per year go to the Coal Area Highway Improvement Account.

5. Ten percent of total collections per year are allocated to the State School Equalization Fund.

6. For the period ending December 31, 1979, 1 percent to the County Land Planning Account.

7. Two and one-half percent per year is earmarked for the Renewable Resource Development Account.

8. Two and one-half percent of total collections per year through June 30, 1979 shall be allocated one-half for the purpose of sites and areas described in Section 62-304 (dealing with

parks) and one-half for the purposes of park acquisition. After June 30, 1979, 5 percent of the total shall be allocated to the purpose of parks acquisition.

9. All other revenues from license or severance taxes collected under this chapter shall be deposited to the credit of the General Fund of the State of Montana except such portions of the severance tax authorized by laws in 1975 to go to earmarked funds. (84:1319)

Taxes imposed on mineral production in Montana are in addition to the ad valorem taxes due. Montana has a classified property tax system in which all property is put in one of 11 classes. All property, except mines and agricultural lands are assessed at 40 percent of full value. Local property taxes are levied on taxable value, however, which is determined by multiplying the assessed value by the particular rate associated with the property class. For Class 1 property, which includes annual net proceeds of all mines except coal mines, taxable value is 100 percent of assessed value. Gross proceeds from underground coal mines are assessed at 33 1/3 percent, and proceeds of strip mines are assessed at 45 percent. (84:301,302)

The 1975 Legislature enacted a measure requiring any person intending to construct a new industrial facility, including a mining facility, to prepay on request an amount not to exceed three times the estimated property tax due the year the facility is completed. One-fifth of the amount prepaid will then be allowed as a credit against property taxes in each of the first 5 years of operation of the facility. (C.H. 571, Laws of 1975)

APPENDIX G

Uranium Report to the
Governor and the 1977 Legislature
by the Department of Natural Resources
and Conservation

In accordance with a directive from the legislature, the Department of Natural Resources and Conservation prepared a report entitled, "Uranium Solution Extraction: The Process and the Law, February, 1977" which details DNRC's authority and the authority of other State and Federal agencies to control or regulate solution mining of uranium. The report contains uranium-related recommendations to the Governor and the 1977 Legislature and includes provisions for the moratorium on solution mining of uranium (ending April, 1978).

The material for Appendix G was excerpted solely from the above report, Reference (30).

In accordance with the State policy to provide protection for Montana's land and water resources, the 44th Legislative Assembly in 1975 enacted Senate Bill No. 374 designed to control uranium solution extraction and the rehabilitation of lands and waters thereby affected.

The highlights of Senate Bill 374 include the following points: (1) that in Montana uranium exploration is increasing, and previously non-economical deposits are now being considered worthy of development due to rising National and world prices; (2) that many Montana uranium deposits are located so deep and of such a configuration that economical recovery is only possible through solution mining; (3) that energy companies have shown an interest in development of Montana uranium deposits through use of solution mining; (4) that pilot projects involving solution mining of uranium are being seriously undertaken (in states other than Montana) and that contamination of fresh water resources is occurring; (5) that solution extraction of uranium constitutes a technologically feasible method of uranium extraction which threatens Montana's land and water resources to the detriment of existing and projected agricultural, recreational, domestic, and other uses; and (6) that the Legislature, pursuant to its mandate and authority

under Article IX of the Montana Constitution declares that it is the policy of the State to provide for the protection of the lands and waters of the State and therefore to make provisions for the control of uranium solution extraction and rehabilitation of lands and waters affected by this extraction (when and where applicable).

The DNRC report contains a statement from the Montana Energy Advisory Council as follows: "There have been no discoveries of commercial quality uranium ore in Montana. Adoption of solution mining techniques for development of uranium ores may change the definition of "commercial quality" ore. Should this occur ... likely areas for discovery of exploitable uranium ore in Montana lie within the Big Hole drainage, the Ruby Valley, and the Carbon County quadrant in eastern Montana. Some quantities of pitchblende have been noted in northwestern Montana near the Idaho border."

Other reports indicate that mineable deposits of commercial quality uranium ore may exist in Montana. How one defines the key term (commercial ore) determines which view he accepts as being true.

The DNRC report covers many important aspects of uranium solution mining; these selected excerpts of Appendix G were chosen to offer discussions that are not addressed elsewhere in the Uranium Report.

## Authority of Federal Agencies

Solution mining of uranium is licensed by the Federal Government under the Atomic Energy Act of 1954. Solution mining is also under the jurisdiction of the Mining Enforcement and Safety Administration (MESA) of the U.S. Department of the Interior.

Basically, the federal legislation concerns:

(1) The regulation of the production and utilization of atomic energy, special nuclear material, and source material (regulated by the Nuclear Regulatory Commission), and

(2) The prescription of health and safety standards for the protection of life, the promotion of health and safety, and the prevention of accidents concerning individuals operating the mining facilities regulated by MESA .

The Atomic Energy Act allows the State to enter into an agreement with the Nuclear Regulatory Commission (formerly the Atomic Energy Commission) whereby the State may exercise regulatory authority over all sources of radiation, except in instances dealing with source and special nuclear materials in quantities of citical mass. Such States are generally referred to as "Agreement States."

In order to become an "Agreement State," the Governor of the State must certify that the State has a program for the control of radiation hazards, and that the State desires to assume regulatory responsibilities. The Commission must then find that the State program is compatible with the Commission's program for regulation of the materials, and that the State program is adequate to protect the public health and safety with respect to the materials covered by the proposed agreement.

In states which do not agree to do their own radioactive source material licensing (commonly referred to as "Non-Agreement States"), uranium solution mining is classified as a "mill," which is subject to the federal licensing process. However, even in the case of "Non-Agreement States," the federal government has not assumed all authority to regulate uranium extraction mining. Any State, whether an "Agreement State" or a "Non-Agreement State," retains the authority to legislate for the regulation of activites and protection of the health and safety of its citizens (other than protection against radiation hazards).

## Authority of Montana Agencies

Under the Radiation Control Act, Montana has the authority to enter into an agreement with the federal government. However, because that authority has not been exercised, Montana is a "Non-Agreement State" and cannot administer radioactive source licensing. Consequently, solution mining of uranium in Montana would be licensed under regulations of the federal Atomic Energy Act. Such an operation would also be under the jurisdiction of MESA and, therefore, subject to MESA regulations.

Nevertheless, except in matters of radiation hazards, Montana has

the authority to enact legislation regulating uranium solution mining for the protection of the health and safety of State residents. Therefore, the question is whether existing State laws and rules provide for control of the uranium solution extraction process and the rehabilitation of the lands and water thereby affected.

Department of State Lands

The mining reclamation laws which are in effect in Montana do not provide for the control mandated. Such laws specifically exempt either the mineral (uranium) or the process followed in the extraction of the mineral (injection of a solvent into zones below the earth's surface and subsequent withdrawal of the solution) from the scope of the legislation. Therefore, the Department of State Lands does not presently have the authority to control or regulate solution extraction of uranium.

Department of Natural Resources and Conservation

With regard to mining activites involving State waters, the Department of Natural Resources and Conservation has enforcement authority under both the Montana Ground Water Code (Section 89-2911 *et seq.*, R.C.M. 1947) and the Montana Water Use Act (Section 89-865 *et seq.*, R.C.M. 1947). The Montana Major Facility Siting Act (Section 70-801 *et seq.*, R.C.M. 1947) is also administered by this Department. The issue of immediate concern is whether these laws can be invoked to meet the legislative mandate of the Uranium Solution Extraction Act.

Ground Water Code. Under this law, mining is a beneficial use for which ground water may be appropriated. The Department has no authority under the Ground Water Code to license or permit mining activities that require the injection of a solvent into an aquifer and thereby contaminate the waters of the aquifer; in fact, the Department is mandated to order wells producing waters which contaminate other waters to be plugged or capped. The power is not discretionary. Therefore, while the Ground Water Code probably does not prohibit solution mining activities, neither is it a practical alternative for regulating those activities.

Water Use Act. The purpose of this law is to provide for the

administration, control, and regulation of water rights and the establishment of a centralized recording system of all water rights.

As related to uranium solution mining, any diversion, impoundment, or withdrawal of waters for this purpose must be made in accordance with the Water Use Act. If the operator does not have an existing water right, a permit must be secured to appropriate the water necessary for the beneficial use (in this case, the mining process).

The Water Use Act authorizes the Board of Natural Resources and Conservation to adopt rules to regulate the construction, use, and sealing of wells to prevent the waste, contamination, or pollution of ground water. A "well" is defined in this statute as "any artificial opening or excavation in the ground, however made, by which ground water is sought or through which it flows under natural pressures or is artificially withdrawn." It therefore appears that the Board's rule-making authority may be sufficiently broad to allow adoption of regulations concerning the use of wells in a solution extraction mining process which involves an aquifer; no such rules have been adopted.

Furthermore, the Board's authority to regulate solution extraction mining under the provisions of this rule-making authorization may be questioned from the standpoint that the rules must provide for the prevention of waste, contamination, or pollution of ground water. The fact is that the introduction of a foreign solution into an uranium-bearing zone will materially change the character of any ground water in that zone. Consequently, the ground water is routinely contaminated, at least during the active mining operation. In effect, adopting rules under provisions of the Water Use Act to govern solution extraction mining (i.e., allowing contamination at least during the life of the mining operation) would be equal to allowing an activity that the act is apparently designed to prevent (i.e., contaminating ground water in light of a statute calling for the prevention of such contamination).

It must be noted that, if it is determined that a State agency other than the Department of Natural Resources and Conservation should regulate uranium solution mining in Montana, water appropriations necessary for the mining operations would remain the jurisdiction of the Department of Natural Resources and Conservation.

Major Facility Siting Act. Arguably, the Department (DNRC) and the Board of Natural Resources and Conservation may have authority to regulate uranium solution mining under terms of the Montana Major Facility Siting Act. In this statute, one of the definitions of "facility" is a "plant...designed for, or capable of, enriching uranium minerals, or any addition thereto..." If the phrase "enriching uranium minerals" can be interpreted to mean the concentrating of uranium, the Board of Natural Resources and Conservation must certify such a facility and condition its construction, operation, and maintenance so as to provide for the control of uranium solution extraction and the protection and rehabilitation of lands and waters thereby affected.

Department of Health and Environmental Sciences

The Department of Health and Environmental Sciences' possible authority to regulate the uranium solution extraction process can be assessed by examining two statutes.

Radiation Control Act. As previously noted, this 1967 legislation authorized the Governor, on behalf of the state, to enter into agreements with the federal government which would allow the state to exercise regulatory authority over all sources of radiation. The act also named the Department of Health and Environmental Sciences as the state radiation control agency. As such, the Department of Health and Environmental Sciences has the authority to develop programs and adopt rules with regard to compatibility with Federal programs for licensing and regulation of by-product, source, radioactive waste materials, and other radioactive materials. In part, such rules are intended to cover equipment and facilities.

The State of Arizona, under a statute (Section 30-651 *et seq.*, Arizona Revised Statutes) similar to that of Montana, has assumed the responsibility for issuing licenses for uranium mining. In Arizona licensure process, the Arizona Atomic Energy Commission administratively builds requirements into an application as it is processed. Thus, the concerns of the various Arizona state agencies are answered before a radioactive materials license is issued.

The rule-making authority given to the Department of Health and Environmental Sciences by the Radiation Control Act is quite broad:

(1) The Department (DHES) is the State radiation control agency.

(2) Under the laws of this State, the Department may employ, compensate, and prescribe the powers and duties of the individuals which are necessary to carry out this act.

(3) The Department may for the protection of the occupational public health safety:

(a) Develop and conduct programs for evaluation and control of hazards associated with the use of sources of ionizing radiation.

(b) Develop programs and adopt rules with due regard for compatibility with federal programs for licensing and regulation of by-product, source, radioactive waste materials, and other radioactive materials. These rules shall cover equipment and facilities, methods for transporting, handling and storage of radioactive materials, permissible levels of exposure, technical qualifications of personnel, required notification of accidents and other incidents involving radioactive materials, survey methods and results, methods of disposal of radioactive materials, posting and labeling of areas, and sources, and methods, and effectiveness of controlling individuals in posted and restricted areas.

(c) Adopt rules relating to control of other sources of ionizing radiation. These rules shall cover equipment and facilities, permissible levels of exposure to personnel, posting of areas, surveys, and records.

(d) Advise, consult, and co-operate with other agencies of the state, federal government, other states, interstate agencies, political subdivisions, and with groups concerned with control of sources of ionizing radiation.

(e) Accept and administer loans, grants, or other funds or gifts, conditional or otherwise, in furtherance of its functions, from the Federal Government and from other sources, public or private.

(f) Encourage, participate in, or conduct studies, investigations, training, research, and demonstrations, relating to control of sources of ionizing radiation.

(g) Collect and disseminate information relating to control of sources of ionizing radiation, including:

(i) Maintenance of a file of all license applications, issuances, denials, amendments, transfers, renewals, modifications, suspensions, and revocations;

(ii) Maintenance of a file of registrants possessing sources of ionizing radiation requiring registra-

tion under this act and any administrative or judicial action pertaining thereto;

(iii) Maintenance of a file of all rules relating to regulation of sources of ionizing radiation, pending or adopted and proceedings thereon.

-- Section 69-5804, R.C.M. 1947

Source material, by definition, includes uranium. Therefore, it is apparent that the State Radiation Control Agency (Department of Health and Environmental Sciences) has been given the authority to adopt rules for licensing and regulation of uranium solution mining activities; thus far, no such rules have been adopted.

Water Pollution Act. Additionally, the Department of Health and Environmental Sciences is charged with the responsibility of providing a comprehensive program for the prevention, abatement, and control of water pollution in the State of Montana.

Under the Water Pollution Act (Section 69-4801 *et seq.*, R.C.M. 1947), the Board of Health and Environmental Sciences is given rule-making authority to govern issuance of the permits which are required prior to the discharge of "...sewage, industrial wastes, or other wastes into any state waters." The Department of Health and Environmental Sciences has the correlative authority to issue, suspend, revoke, modify or deny these permits consistent with the rules made by the Board. Such rules governing ground water are in the process of being drafted, but have not yet been adopted.

By statutory definition, the term "other wastes" includes "...all other substances that may pollute state waters." "Pollution" is defined as meaning:

> ...contamination ("impairment of the quality of state waters by sewage, industrial wastes or other wastes creating a hazard to human health"), or other alteration of the physical, chemical, or biological properties of any state waters, which exceeds that permitted by Montana water quality standards, including, but not limited to, standards relating to change in temperature, taste, color, turbidity, or odor; or discharge of any liquid, gaseous, solid, radioactive, or other substance into any state water which will

> or is likely to create a nuisance or render injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
>
> -- Section 69-4802, R.C.M. 1947

If an aquifer is involved, the injection of a solution into the uranium ore-bearing body would result in discharge of waste into state waters. Therefore, the mining process, at least any portion of a process which would impair the quality of state water, would fall within the scope of the Water Pollution Act.

## Conclusions and Recommendations

From the above discussion, it is apparent that the Board and the Department of Health and Environmental Sciences presently have the authority, under two separate legislative enactments, to regulate uranium solution mining in the State of Montana. Those entities have a broad grant of authority which could be exercised to provide both for the control of the extraction process and for the protection and rehabilitation of the waters thereby affected. Therefore, it does not appear that comprehensive uranium solution mining legislation need be enacted by the Legislature, but it is recommended that the Department and the Board of Health and Environmental Sciences exercise their existing rule-making authority to regulate solution mining.

In addition, because it is not certain that the Board of Health and Environmental Sciences has sufficient authority to protect and rehabilitate the lands affected by uranium solution extraction. It is further recommended that the 1977 Legislative Session consider giving the Board of Health and Environmental Sciences authority to adopt rules and regulations which would clearly provide for the protection and rehabilitation of the lands affected by uranium solution extraction operations.

It is further recommended that the Major Facility Siting Act be amended to replace the phrase "enriching uranium minerals" with the phrase "isotope enrichment," thereby removing any doubt as to the type of facility covered by the Siting Act.

APPENDIX H

## Glossary of Nuclear Energy Terms

The following definitions were obtained from the U.S. Atomic Energy Commission and the Lake Michigan Federation bulletin.

Accelerator.....A device for increasing the velocity and energy of charged elementary particles, for example, electrons or protons, through application of electrical and/or magnetic forces. Accelerators have made particles move at velocities approaching the speed of light.

ACRS.....An entity within the Atomic Energy Commission
(Advisory Committee on Reactor Safeguards) (now the Nuclear Regulatory Commission) that must review each application for a reactor license.

Activation.....The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles. Also called "radioactivation."

AEC (Atomic Energy.....The federal agency created by the Atomic
Commission) Energy Act of 1954 that had the responsibilities for both promotion and regulation of
NRC (Nuclear Regulatory nuclear power. As of January, 1975, the AEC
Commission) became defunct under that name. The promotion and development of nuclear power (and other energy sources - primarily coal) became the responsibility of the newly established ERDA, Energy Research and Development Administration. The Nuclear Regulatory Commission (NRC) was also formed at this time, to regulate the nuclear power industry.

Afterheat.....The heat produced by the continuing decay of radioactive atoms in a reactor after fission has stopped. Most of the afterheat is due to the radioactive decay of fission products.

Air Sampling.....The collection and analysis of samples of air to measure its radioactivity or to detect the presence of radioactive substances.

ANS.....A private professional society established to
(American Nuclear Socity) integrate science and engineering in the promotion of nuclear technology.

Alpha Particle.....A positively charged particle emitted by certain radioactive materials. It is made up of two neutrons and two protons bound together, hence is identical with the nucleus of a helium atom. It is the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive material, being stopped by a sheet of paper. It is not dangerous to plants, animal or man unless the alph-emitting substance has entered the body.

Atom.....A particle of matter indivisible by chemical means. It is the fundamental building block of the chemical elements. The elements, such as iron, lead, and sulfur, differ from each other because they contain different kinds of atoms. There are about six sextillion atoms in an ordinary drop of water. According to present-day theory, an atom contains a dense inner core (the nucleus) and a much less dense outer domain consisting of electrons in motion around the nucleus. Atoms are electrically neutral.

Atomic Bomb.....A bomb whose energy comes from the fission of heavy elements, such as uranium or plutonium.

Atomic Cloud.....The cloud of hot gasses, smoke, dust, and other matter that is carried aloft after the explosion of a nuclear weapon in the air or near the surface. The cloud frequently has a mushroom shape.

AIF.....An organization of over 600 companies, agencies, and groups involved in promoting use of nuclear energy for peaceful purposes.
(Atomic Industrial Forum)

Atomic Safety and.....A board appointed by the Atomic Energy Commission to conduct hearings on license application for each nuclear power plant.
Licensing Board

Atomic Safety and Li-....An appeal body within the AEC to which decisions of Atomic Safety and Licensing are reviewed by the AEC commissioners.
censing Appeal Board

Atomic Weapon.....An explosive weapon in which the energy is produced by nuclear fission or fusion.

Availability Factor.....See "Plant Availability"

Background Radiation.....The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of men and animals. It

is also called natural radiation. The term also means radiation that is unrelated to a specific experiment.

Beta Particle.....An elementary particle emitted from a nucleus during radioactive decay, with a single electrical charge and a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation may cause skin burns, and beta-emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal, however.

Binding Energy.....The binding energy of a nucleus is the minimum energy required to dissociate it into its component neutrons and protons. Neutron or proton binding energies are those required to remove a neutron or a proton, respectively, from a nucleus. Electron binding energy is that required to remove an electron from an atom or a molecule.

Biological Dose.....The radiation dose absorbed in biological material. Measured in rems.

Biological Half-Life.....The time required for a biological system, such as a man or an animal, to eliminate, by natural processes, half the amount of a substance (such as a radioactive material) that has entered it.

Body Burden.....The amount of radioactive material present in the body of a man or an animal.

BWR.....The type of nuclear reactor in which water is
(Boiling Water Reactor) converted to steam in the reactor vessel.

Bone Seeker.....A radioisotope that tends to accumulate in the bones when it is introduced into the body. An example is strontium-90, which behaves chemically like calcium.

Breeder Reactor.....A type of reactor now under development that would breed more fuel than it would consume, for example, by transmuting stable U-238 to fissionable Plutonium.

Breeding.....In a natural uranium reactor though the fissile U-235 is consumed during operation, new fissile material, Pu-239 is simultaneously produced by neutron capture in U-238. If the neutron economy in the reactor were very good there

could be more plutonium produced than U-235 consumed.

BTU (British Thermal Unit)..... The amount of energy required to heat one pound of water by 1° F.

Calvert Cliffs Case..... A Federal Appeals Court case which forced the AEC to implement the National Environmental Act of 1969, and examine all aspects of environmental impact in licensing nuclear power plants.

Capacity Factor..... See "Plant Capacity."

Chain Reaction..... A reaction that stimulates its own repetition. In a fission chain reaction a fissionable nucleus absorbs a neutron and fissions, releasing additional neutrons. These in turn can be absorbed by other fissionable nuclei, releasing still more neutrons. A fission chain reaction is self-sustaining when the number of neutrons released in a given time equals or exceeds the number of neutrons lost by absorption in nonfissioning material or by escape from the system.

China Accident..... See "Maximum Hypothetical Accident"

Cladding, Fuel..... A metallic coating on fuel rods intended to prevent leaks of the radioactive fuel into the cooling water within the reactor vessel.

Closed Cycle Cooling..... A power plant cooling system that recycles cooling water.

Closed Cycle Reactor System..... A reactor design in which the primary heat of fission is transferred outside the reactor core to do useful work by means of a coolant circulating in a completely closed system that includes a heat exchanger.

Comment Period..... The period of 30-60 days allowed by the AEC for public comment before putting a new regulation into effect.

Construction Permit..... A permit granted by the AEC for construction of a nuclear power plant.

Containment Vessel..... A large concrete or steel shell around the reactor intended to contain radiation in the event of an accident.

Control Rod..... A rod, plate, or tube containing a material that readily absorbs neutrons (hafnium, boron,

etc), used to control the power of a nuclear reactor. By absorbing neutrons, a control rod prevents the neutrons from causing further fission.

Coolant.....A substance circulated through a nuclear reactor to remove or transfer heat. Common coolants are water, air, carbon dioxide, liquid sodium and sodium-potassium alloy.

Cooling Pond.....A tank of water used at reactor installations for dumping spent or faulty fuel elements after irradiation. The tank is so fitted that these highly radioactive materials can be manipulated underwater by an operator standing above the tank and shielded from radiation by a depth of water. Cooling ponds are also used for storage of spent fuel elements until such a time as a large proportion of the radioactivity has decayed.

Cooling Tower.....A tower-like structure used to cool water for use in a closed-cycle cooling system.

Critical Mass.....The smallest mass of fissionable material that will support a self-sustaining chain reaction under stated conditions.

Criticality.....The state of a nuclear reactor when it is sustaining a chain reaction.

Crud.....In corrosion problems, crud may be defined as particulate corrosion products carried in suspension and deposited on the surfaces of circulating water systems.

Decay, Radioactive.....The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in a decrease, with time, of the number of the original radioactive atoms in a sample. It involves the emission from the nucleus of alpha particles, beta particles (or electrons), or gamma rays; or the nuclear capture or ejection of orbital electrons; or fission. Also called radioactive disintegration.

Decontamination.....The removal of radioactive contaminants from surfaces or equipment, as by cleaning and washing with chemicals.

Degraded Fuel.....Fuel rods which have ruptured with resultant leakage of radioactivity into the reactor coolant.

Depleted Uranium.....Uranium having a smaller percentage of uranium-235 than the 0.7% found in natural uranium. It is obtained from the spent (used) fuel elements or as by-product trails, or residues, of uranium isotope separation.

Derating.....Restriction of power output of a nuclear power plant to less than the design capacity as a safety measure.

Direct-Cycle Reactor System.....A nuclear power plant system in which the coolant or heat transfer fluid circulates first through the reactor and directly to a turbine.

Doubling Time.....The time required for a breeder reactor to produce as much fissionable material as the amount usually contained in its core plus the amount tied up in its fuel cycle (fabrication, reprocessing, etc). It is estimated as 10 to 20 years in typical reactors.

ECCS (Emergency Core Cooling System).....A safety system designed to spray or flood a nuclear fuel core to prevent melting of the fuel in the event of a Loss of Coolant Accident (LOCA).

Enriched Material.....Material in which the percentage of a given isotope present in a material has been artificially increased, so that it is higher than the percentage of that isotope naturally found in the material. Enriched uranium contains more of the fissionable isotope uranium-235 than the naturally occurring percentage (0.7%).

Enrico Fermi Breeder Reactor.....The first experimental breeder reactor built near Detroit. In 1966 an engineering accident caused the plant to be shut down for four years. This plant is being dismantled permanently.

Environmental Impact Statement.....A description of adverse environmental effects and commitment of resources, with consideration of alternatives, required under the NEPA for all federally sponsored projects with significant environmental effects.

Environmental Report.....The report the applicant for a license for a nuclear plant must submit to the AEC. It is used by the AEC in preparing an evironmental impact statement.

Fallout.....Air-borne particles containing radioactive material which fall to the ground following a nuclear explosion. "Local fallout" from nuclear detonations falls to the earth's surface within 24 hours after the detonation. "Tropospheric fallout" consists of material injected into the troposphere but not into the higher altitudes of the stratosphere. It does not fall out locally, but usually is deposited in relatively narrow bands around the earth at about the latitude of injection. "Stratospheric fallout" or "worldwide fallout" is that which is injected into the stratosphere and which then falls out relatively slowly over much of the earth's surface.

Fast Breeder Reactor.....A reactor that operates with fast neutrons and produces more fissionable material than it consumes.

Federal Radiation Council.....A now defunct federal agency formerly responsible for setting radiation guidelines, which are now the responsibility of the Environmental Protection Agency.

FSAR (Final Safety Analysis Report).....The final report submitted by the applicant for a license for a nuclear power plant to the AEC, showing all changes in design of safety systems and quality control measures required by the AEC as the result of evaluation of the PSAR.

Fissile Material.....While sometimes used as a synonym for fissionable material, this term has also acquired a more restricted meaning, namely, any material fissionable by neutrons of all energies, including (and especially) thermal (slow) neutrons as well as fast neutrons; for example, uranium-235 and plutonium-239.

Fission.....The splitting of a heavy nucleus into two approximately equal parts (which are nuclei of lighter elements), accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously, but usually is caused by nuclear absorption of gamma rays, neutrons or other particles.

Fission Products.....The nuclei formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

Fissionable Material.....Commonly used as a synonym for fissile material. The meaning of this term also has been extended to include material that can be fissioned by fast neutrons only, such as uranium-238. Used in reactor operations to mean fuel.

Fuel Densification.....Shrinkage of uranium fuel in fuel rods, leaving portions of the fuel rod empty.

Fuel Assembly.....A group of 12 foot long fuel rods, usually about 180 per reactor.

Fuel Rod.....A ½ inch in diameter rod 12 feet long containing uranium fuel pellets.

Fusion.....Fusing of two or more atoms into a single atom with release of stored energy; the opposite of fission.

Gamma Rays.....High-energy, short-wavelength electromagnetic radiation. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or depleted uranium. Gamma rays are essentially similar to X rays, but are usually more energetic, and are nuclear in origin.

Gas Centrifuge Process...A method of isotopic separation in which heavy gaseous atoms or molecules are separated from light ones by centrifugal force.

Gas Cooled Reactor.....A nuclear reactor in which a gas is the coolant.

Gaseous Diffusion.....A method of isotopic separation based on the
Plant fact that gas atoms or molecules with different masses will diffuse through a porous barrier (or membrane) at different rates. The method is used by the AEC to separate uranium-235 from uranium-238; it requires large gaseous-diffusion plants and enormous amounts of electric power.

GAO.....The agency that serves as the Congressional
(General Account Office) watchdog on Federal spending.

Gaseous Wastes-.....These are released at the metal dissolution
Radioactive stage and the main components are radioiodine 131 and the radioactive noble gases, Xenon 131 and Krypton 85. Associated with these are inactive water vapor and oxides of nitrogen

together with entrained particulate radioactive matter in the form of aerosols etc.

Genetic Effects of Radiation.....Radiation effects that can be transferred from parent to offspring. Any radiation-caused changes in the genetic material of sex cells.

Glove Box.....A sealed box in which workers, using gloves attached to and passing through opening in the box, can handle radioactive materials safely from the outside.

Graphite.....A very pure form of carbon used as a moderator in nuclear reactors.

Ground Zero.....The point on the surface of land or water vertically below or above the center of a burst of a nuclear explosion. For a burst over or under water, the term surface zero is preferable.

Half-life.....The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years.

Half-life, Effective.....The time required for a radionuclide contained in a biological system, such as a man or an animal, to reduce its activity by half as a combined result of radioactive decay and biological elimination.

Hand and Foot Counter....A monitoring device arranged to give a rapid radiation survey of hands and feet of persons working with radioactive materials, to detect radioactive contamination.

Health Physics.....The science concerned with recognition, evaluation, and control of health hazards from ionizing radiation.

Heat Exchanger.....Any device that transfers heat from one fluid (liquid or gas) to another or to the environment.

Heat Sink.....Anything that absorbs heat; usually part of the environment, such as the air, a river, or outer space.

Heavy Hydrogen.....Deuterium

Heavy Water.....Water containing significantly more than the natural proportion (one in 6500) of heavy hydrogen (deuterium) atoms to ordinary hydrogen

atoms. Heavy water is used as a moderator in some reactors because it slows down neutrons effectively and also has a low cross section for absorption of neutrons.

Heavy-water Moderated Reactor....A reactor that uses heavy water as its moderator. Heavy water is an excellent moderator and thus permits the use of inexpensive natural (unenriched) uranium as a fuel.

Heterogeneous Reactor....A reactor in which the fuel is separate from the moderator and is arranged in discrete bodies, such as fuel elements. Most reactors are heterogeneous.

Homogeneous Reactor.....A reactor in which the fuel is mixed with or dissolved in the moderator or coolant. Example: A fused-salt reactor.

Hot.....Highly radioactive.

Hot Spot.....A surface area of higher-than-average radioactivity. Also a part of a fuel element surface that has become overheated.

Hydrogen.....The lightest element, No. 1 in the atomic series. It has two natural isotopes of atomic weights 1 and 2. The first is ordinary hydrogen, or light hydrogen; the second is a deuterium, or heavy hydrogen. A third isotope, tritium, atomic weight 3, is a radioactive form produced in reactors by bombarding lithium-6 with neutrons.

Hydrogen Bomb.....A nuclear weapon that derives its energy largely from fusion.

Ion.....An atom or molecule that has lost or gained one or more electrons. By this ionization it becomes electrically charged. Examples: an alpha particle, which is a helium atom minus two electrons; a proton, which is a hydrogen atom minus its electron.

Ion Engine.....An engine which provides thrust by expelling accelerated or high velocity ions. Ion engines using energy provided by nuclear reactors are proposed for space vehicles.

Ionization.....The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiations can cause ionization.

Impulsion Weapon.....A weapon in which a quantity of fissionable material, less than a critical mass at ordinary pressure, has its volume suddenly reduced by compression (a step accomplished by using chemical explosives) so that it becomes supercritical, producing a nuclear explosion.

Indirect-cycle Reactor System.....A reactor system in which a heat exchanger transfers heat from the reactor coolant to a second fluid which then drives a turbine.

Initial Nuclear Radiation.....Radiation emitted from the fireball of a nuclear explosive during the first minute (an arbitrary time interval) after detonation.

Interim Criteria.....The criteria for evaluating effectiveness of Emergency Core Cooling Systems, pending conclusion of hearings by the AEC following failure of a series of tests in 1971.

Intake Pipes.....The pipes through which cooling water is withdrawn from a waterway.

Intervenor.....The legal designation of a participant in AEC rule-making or license hearing, other than the AEC staff, the applicant for a license, or the Atomic Safety and Licensing Board.

Intervention.....The process under AEC regulations to provide access to AEC license of rule-making procedures for interested parties other than the AEC staff, license applicant or Atomic Safety and Licensing Board.

Ionizing Radiation.....Any radiation displacing electrons from atoms or molecules, thereby producing ions. Examples: alpha, beta, gamma radiation, short-wave ultraviolet light. Ionizing radiation may produce severe skin or tissue damage.

Isotope.....One or two or more atoms with the same atomic number (the same chemical element) but with different atomic weights. An equivalent statement is that the nuclei of isotopes have the same number of protons but different numbers of neutrons. Isotopes usually have very nearly the same chemical properties, but somewhat different physical properties.

Isotope Separation.....The process of separating isotopes from one another, or changing their relative abundances, as by gaseous diffusion or electromagnetic separation. All systems are based on the mass differences of the isotopes. Isotope separation

is a step in the isotopic enrichment process.

Isotopic Enrichment.....A process by which the relative abundances of the isotopes of a given element are altered, thus producing a form of the element which has been enriched in one particular isotope. Example: enriching natural uranium in the uranium-235 isotope.

Joint Committee on Atomic Energy.....A joint congressional committee which oversees the AEC.

Kinetic Energy.....Energy due to motion.

Kilowatt.....A thousand watts.

Kilowatt Hour.....A unit of energy equal to that expended by one kilowatt in one hour.

Leakage.....In nuclear engineering, the escape of neutrons from a reactor core. Leakage lowers a reactor's reactivity.

Least Practicable.....A limit on radiation emission from nuclear power plants based on use of maximum available technology to prevent emission.

Lethal Dose.....A dose of ionizing radiation sufficient to cause death. Median lethal dose (MLD or LD-50) is the dose required to kill within a specified period of time (usually 30 days) half of the individuals in a large group of organisms similarly exposed.

LWR (Light Water Reactor).....A reactor type that includes both the boiling water reactor and the pressurized water reactor.

Linear Accelerator.....A long straight tube (or series of tubes) in which charged particles (ordinarily electrons or protons) gain in energy by the action of oscillating electromagnetic fields.

LMFBR (Liquid Metal Fast Breeder Reactor).....A breeder reactor that uses liquid metal, probably sodium, as a coolant.

LOCA (Loss of Coolant Accident).....The worst accident considered possible by the AEC, in which coolant would be lost from the primary cooling system as the result of rupture of the piping.

LOFT (Loss of Fluid Test).....A test designed to reveal ECCS effectiveness under LOCA conditions.

Low Population Zone.....An area of low-population density sometimes required around a nuclear installation. The number and density of residents is of concern in providing, with reasonable probability, that effective protection measures can be taken if a serious accident should occur.

MHD.....Generation of a direct electric current by
(Magnetohydrodynamics) passage of a hot gas through a magnetic field at high velocity. Not yet technologically feasible for commercial use.

Manhatten Project.....The U.S. War Department program during World War II that produced the first atomic bombs. The term originated in the code-name, "Manhattan Engineer District," which was used to conceal the nature of the secret work underway. The Atomic Energy Commission, a civilian agency, succeeded the military unit Jan. 1, 1947.

Manipulators.....Mechanical devices used for safe handling of radioactive materials. Frequently they are remotely operated from behind a protective shield.

Mass.....The quantity of matter in a body. Often used as a synonym for weight, which, strictly speaking, is the force exerted by a body under the influence of gravity.

Matter.....The substance of which a physical object is composed. All materials in the universe have the same inner nature, that is, they are composed of atoms, arraged in different (and often complex) ways; the specific atoms and the specific arrangements identify the various materials.

Maximum Credible.....The most serious reactor accident that can
Accident reasonably be imagined from any adverse combination of equipment malfunction, operating errors, and other foreseeable causes. The term is used to analyze the safety characteristics of a reactor.

Maximum Hypothetical.....An accident in which the reactor pressure
Accident vessel would rupture, followed by rupture of the containment. An accident that the AEC does not analyze on the grounds that it is incredible.

Maximum Permissible Dose (MPD) (Maximum Permissable Exposure).....That dose of ionizing radiation established by competent authorities as an amount below which there is no reasonable expectation of risk to human health, and which at the same time is somewhat below the lowest level at which a definite hazard is believed to exist. (An absolescent term, in the view of some researchers.)

Megaton Energy.....The energy of a nuclear explosion which is equivalent to that of an explosion of one million tons (or 1000 kilotons) of TNT.

Meltdown.....Melting of the reactor fuel core through the bottom of the containment structure because of very rapid rise in temperature that would follow failure of the primary cooling system in a nuclear power plant. Radiation would be released into the atmosphere by hydrogen and steam explosions, and it is believed the reactor core would continue melting down into the earth.

Micro.....A prefix that divides a basic unit by one million.

Milli.....A prefix that divides a basic unit by one thousand.

Moderator.....A material, such as ordinary water, heavy water or graphite, used in a reactor to slow down high-velocity neutrons, thus increasing the likelihood of further fission.

Molecule.....A group of atoms held together by chemical forces. A molecule is the smallest unit of matter that can exist by itself and retain all its chemical properties.

Moratorium (Nuclear).....A delay in the construction of additional nuclear plants.

Mutation.....A permanent transmissible change in the characteristics of an offspring from those of its parents.

National Council of Radiation Protection and Measurements.....A body of physicians and scientists established by Congress in 1929 to set national radiation standards.

National Laboratories....Scientific laboratories sponsored by the federal government. The national laboratories doing research for the AEC are Argonne, Oak Ridge, and Brookhaven.

NRTS (National Reactor Testing Station)..... A facility in Idaho operated by Aerojet Corporation to conduct safety research experiments such as the 1974 LOFT tests under contract to the AEC.

Neutron..... An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen. A free neutron is unstable and decays with a half-life of about 13 minutes into an electron, proton, and neutrino. Neutrons sustain the fission chain reaction in a nuclear reactor.

Nondestructive Testing..... Testing to detect internal and concealed defects in materials using techniques that do not damage or destroy the items being tested. X rays, isotopic radiation and ultrasonics are frequently used.

Nuclear Energy..... The energy liberated by a nuclear reaction (fission or fusion) or by radioactive decay.

Nuclear Explosive..... An explosive based on fission or fusion of atomic nuclei.

Nuclear Fuel Reprocessing..... When reactor fuel is spent, it is removed and taken to a fuel reprocessing plant, where it is broken down, and the remaining fissionable material is salvaged. There are no reprocessing facilities operating at the present time.

Nuclear Power Plant..... Any device, machine, or assembly that converts nuclear energy into some form of useful power, such as mechanical or electrical power. In a nuclear electric power plant, heat produced by a reactor is generally used to make steam to drive a turbine that in turn drives an electric generator.

Nuclear Reaction..... A reaction involving a change in an atomic nucleus, such as fission, fusion, neutron capture, or radioactive decay, as distinct from a chemical reaction, which is limited to changes in the electron structure surrounding the nucleus

Nuclear Reactor..... A device in which a fission chain reaction can be initiated, maintained, and controlled. Its essential component is a core with fissionable fuel. It usually has a moderator, a reflector, shielding, coolant, and control mechanisms. Sometimes called an atomic

"furnace", it is the basic machine of nuclear energy.

Nuclear Rocket.....A rocket powered by an engine that obtains energy for heating a propellant fluid (such as hydrogen) from a nuclear reactor, rather than from chemical combustion.

Nuclear Weapons.....A collective term for atomic bombs and hydrogen bombs. Any weapons based on a nuclear explosive.

Nucleonics.....The science and technology of nuclear energy and its applications.

Nucleus.....The small, positively-charged core of an atom. It is only about 1/10,000 the diameter of the atom but contains nearly all the atom's mass. All nuclei contain both protons and neutrons, except the nucleus of ordinary hydrogen, which consists of a single proton.

Overpressure.....The transient pressure over and above atmospheric pressure caused by a shock wave from a nuclear explosion.

Package Power Reactor....A small nuclear power plant designed to be crated in packages small enough to be conveniently transported to remote locations.

Plowshare.....The Atomic Energy Commission program of research and development on peaceful uses of nuclear explosives. The possible uses include large-scale excavation, such as for canals and harbors, crushing ore bodies, and producing heavy transuranic isotopes. The term is based on a Biblical reference: Isaiah 2: 4. Citizen opposition has largely rendered this program inoperative.

Plutonium.....A heavy, radioactive, highly toxic man-made, metallic element with atomic number 94. Its most important isotope is fissionable plutonium-239, produced by neutron irradiation of uranium-238. It is used for reactor fuel and in atomic weapons.

PBF.....A reactor built at the National Reactor Testing Station to subject nuclear fuel to conditions of abnormal stress to study the behavior of fuel rods before and during an accident.
(Power Burst Facility)

Power Reactor.....A reactor designed to produce useful nuclear power, as distinguished from reactors used

primarily for research or for producing radiation or fissionable materials.

PSAR (Preliminary Safety Analysis Report)..... A report submitted to the regulatory staff of the AEC regarding safety systems and quality control in a nuclear power plant.

Pressure Vessel..... A strong-walled container housing the core of most types of power reactors; it usually also contains moderator, reflector, thermal shield, and control rods.

Pressurized Water Reactor..... A power reactor in which heat is transferred from the core to a heat exchanger by water kept under high pressure to achieve high temperature without boiling in the primary system. Steam is generated in a secondary circuit. Many reactors producing electric power are pressurized water reactors.

Price-Anderson Act..... The law under which the Federal Government provides liability insurance for nuclear power plants.

Production Reactor..... A reactor designed primarily for large-scale production of plutonium-239 by neutron irradiation or uranium-238. Also a reactor used primarily for the production of radioactive isotopes.

Proton..... An elementary particle with a single positive electrical charge and a mass approximately 1837 times that of the electron. The nucleus of an ordinary or light hydrogen atom. Protons are constituents of all nuclei. The atomic number (Z) of an atom is equal to the number of protons in its nucleus.

Radiation..... The emission and propagation of energy through matter or space by means of electromagnetic disturbances which display both wave-like and particle-like behavior; in this context the "particles" are known as photons. Also, the energy so propagated. The term has been extended to include streams of fast-moving particles (alpha and beta particles, free neutrons, cosmic radiation, etc.). Nuclear radiation is that emitted from atomic nuclei in various nuclear reactions, including alpha, beta and gamma radiation and neutrons.

Radiation Accidents..... Accidents resulting in the spread of radioactive material or in the exposure of individuals to radiation.

Radiation Chemistry.....The branch of chemistry that is concerned with the chemical effects, including decomposition, of energetic radiation or particles on matter.

Radiation Damage.....A general term for the harmful effects of radiation.

Radiation Illness.....An acute organic disorder that follows exposure to relatively severe doses of ionizing radiation. It is characterized by nausea, vomiting, diarrhea, blood cell changes, and in later stages by hemorrhage and loss of hair.

Radiation Monitoring.....Continuous or periodic determination of the amount of radiation present in a given area.

Radiation Protection.....Legislation and regulations to protect the public and laboratory or industrial workers against radiation. Also measures to reduce exposure to radiation.

Radiation Protection Guide.....The officially determined radiation doses which should not be exceeded without careful consideration of the reasons for doing so. These standards, established by the Federal Radiation Council, are equivalent to what was formerly called the maximum permissible dose or maximum permissible exposure.

Radiation Shielding.....Reduction of radiation by interposing a shield of absorbing material between any radioactive source and a person, laboratory area, or radiation-sensitive device.

Radiation Source.....Usually a man-made, sealed source of radioactivity used in teletherapy, radiography, as a power source for batteries, or in various types of industrial guages. Machines such as accelerators, and radioisotopic generators and natural radionuclides may also be considered as sources.

Radiation Standards.....Exposure standards, permissible concentrations, rules for safe handling, regulations for transportation, regulations for industrial control of radiation, and control of radiation exposure by legislative means.

Radiation Sterilization..Use of radiation to cause a plant or animal to become sterile, that is, incapable of reproduction. Also the use of radiation to kill all forms of life (especially bacteria) in food, surgical sutures, etc.

Radiation Therapy.....Treatment of disease with any type of radiation. Often called radiotherapy.

Radiation Threshold.....The level of radiation exposure below which it is assumed no biological damage occurs. Some authorities dispute the existence of such a threshold, holding that any level of radiation causes some damage.

Radiation Warning Symbol.....An officially prescribed symbol (a magenta trefoil on a yellow background) which should always be displayed when a radiation hazard exists.

Radiations.....Specific units or types of radiation.

Radioactive Contamination.....Deposition of radioactive material in any place where it may harm persons, spoil experiments, or make products or equipment unsuitable or unsafe for some specific use. The presence of unwanted radioactive matter. Also radioactive material found on the walls of vessels in used-fuel processing plants, or radioactive material that has leaked into a reactor coolant. Often referred to only as contamination.

Rem.....The term means "Radiation Equivalent Man." A unit of measurement for the radiation absorbed by human tissue.

Radioactivity.....The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.

Radioisotope.....A radioactive isotope. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. More than 1300 natural and artificial radioisotopes have been identified.

Radiology.....The science which deals with the use of all forms of ionizing radiation in the diagnosis and the treatment of disease.

Radium.....A radioactive metallic element with atomic number 88. As found in nature, the most common isotope has an atomic weight of 226. It occurs in minute quantities associated with uranium in pitchblende, carnotite, and other minerals; the uranium decays to radium in a series of alpha and beta emissions. By virtue of being an alph-and gamma-emitter, radium is used as a source of luminescence and as a

radiation source in medicine and radiography.

Radon.....(Symbol Rn) A radioactive element, one of the heaviest gases known. Its atomic number is 86, and its atomic weight is 222. It is a daughter of radium in the uranium radioactive series.

Research Reactor.....A reactor primarily designed to supply neutrons or other ionizing radiation for experimental purposes. It may also be used for training, materials testing, and production of radioisotopes.

Residence Time.....The time during which radioactive material remains in the atmosphere following the detonation of a nuclear explosive. It is usually expressed as a half-time, since the time for all material to leave the atmosphere is not well known.

Rule-making Hearing.....A hearing by a regulatory body, such as the NRC, to gather information for promulgating or revising regulations.

Scram.....The sudden shutdown of a nuclear reactor, usually by rapid insertion of the safety rods. Emergencies or deviations from normal reactor operation cause the reactor operator or automatic control equipment to scram the reactor.

Shock Wave.....A pressure pulse in air, water or earth, propagated from an explosion, which has two phases: in the first, or positive phase, the pressure rises sharply to a peak, then subsides to the normal pressure of the surrounding medium; in the second, or negative phase, the pressure falls below that of the medium, then returns. A shock wave in air usually is called a blast wave.

SNAP.....(Acronym for Systems for Nuclear Auxiliary Power.) A program to develop small auxiliary nuclear power sources for specialized space, land, and sea uses. Two approaches are employed: the first uses heat from radioisotope decay to produce electricity directly by thermoelectric or thermionic methods; the second uses heat from small reactors to produce electricity by thermoelectric or thermionic methods or by turning a small turbine and electric generator.

Somatic Effects.....Effects of radiation limited to the exposed individual, as distinguished from genetic

effects (which also affect subsequent, unexposed generations). Large radiation doses can be fatal. Smaller doses may make the individual noticeably ill, may merely produce temporary changes in blood-cell levels detectable only in the laboratory, or may produce no detectable effects whatever. Also called physiological effects of radiation.

Special Nuclear Material.....In atomic energy law, this term refers to plutonium-239, uranium-233, uranium containing more than the natural abundance of uranium-235, or any material artificially enriched in any of these substances.

Spent (depleted)Fuel.....Nuclear reactor fuel that has been irradiated (used) to the extent that it can no longer effectively sustain a chain reaction.

Test Reactor.....A reactor specially designed to test the behavior of materials and components under the neutron and gamma fluxes and temperature conditions of an operating reactor.

Thermal Efficiency.....The ratio of the electric power produced by a power plant to the amount of heat produced by the fuel; a measure of the efficiency with which the plant converts thermal to electrical energy.

Thermal Pollution.....Heat discharged into an ecosystem causing pathological changes.

Thermonuclear Bomb (device).....A hydrogen bomb (device).

Thermonuclear Reaction...A reaction in which very high temperatures bring about the fusion of two light nuclei to form the nucleus of a heavier atom, releasing a large amount of energy. In a hydrogen bomb, the high temperature to initiate the thermonuclear reaction is produced by a preliminary fission reaction.

Thorium.....A naturally radioactive element with atomic number 90 and, as found in nature, an atomic weight of approximately 232. The fertile thorium-232 isotope is abundant and can be transmuted to fissionable uranium-233 by neutron irradiation.

Waste, Radioactive.....Equipment and materials (from nuclear operations) which are radioactive and for which there is no further use. Wastes are generally

classified as high-level (having radioactivity concentrations of hundreds to thousands of curies per gallon or cubic foot), low-level (in the range of 1 microcurie per gallon or cubic foot), or intermediate (between these extremes).

Watt.....A measure of work accomplished by a current of one ampere under a pressure of one volt.

X-ray.....A penetrating form of electromagnetic radiation emitted either when the inner orbital electrons of an excited atom return to their normal state (these are characteristic X rays), or when a metal target is bombarded with high speed electrons (these are bremsstrahlung). X rays are always nonnuclear in origin.

Yield.....The total energy released in a nuclear explosion. It is usually expressed in equivalent tons of TNT (the quantity of TNT required to produce a corresponding amount of energy). Low yield is generally considered to be less than 20 kilotons; intermediate yield from 200 kilotons to 1 megaton. There is no standardized term to cover yields from 1 megaton upward.

## APPENDIX I

### Nuclear Fuel and Uranium Resources

The material of Appendix I was excerpted solely from Reference (31).

### Nuclear Fuel Cycle

Although the nuclear fuel cycle for light water reactors is sometimes ignored, it is a crucial part of the energy problem. It consists of the following steps. (Figure I-1)

- Exploration for and discovery of uranium ore reserves.
- Mining, milling, and refining the ore to produce uranium concentrates ($U_3O_8$).
- Conversion of $U_3O_8$ to uranium hexafluoride ($UF_6$) to provide feed for uranium enrichment.
- Isotopic enrichment of $UF_6$ to provide reactor grade uranium fuel.
- Fabrication of nuclear fuel, including converting $UF_6$ to uranium dioxide, pelletizing, encapsulating in rods, and assembling the uranium dioxide into fuel elements.
- Loading of fuel into reactors and utilizing the heat for electricity generation.
- Reprocessing the spent fuel to recover remaining fissionable uranium and plutonium from radioactive wastes.
- Converting uranium to $UF_6$ for recycling to enrichment plants and plutonium for use in mixed (plutonium-uranium) oxide fuels.
- Radioactive waste disposal.

While the basic technology for the Light Water Reactor (LWR) fuel cycle is well developed, segments of the fuel cycle are affected by a number of complex, interrelated problems which must be resolved to ensure that necessary supporting functions do not impede the use of nuclear power. The purpose of Appendix I is to discuss some of the problems that relate to the nuclear fuel cycle.

### Uranium Reserves and Resources

As is true for other resource estimates, there is considerable uncertainty about the total size of the domestic uranium resource base. Considerable exploration for uranium was conducted in the early 1950's by the Atomic Energy Commission and the U.S. Geological Survey with a subsequent major effort by private industry. In the period 1967-69, exploration efforts escalated well above the levels of the 1950's, followed by decreased exploration in the early 1970's due to softening in the uranium market. Starting in 1973, exploration activities began to increase once

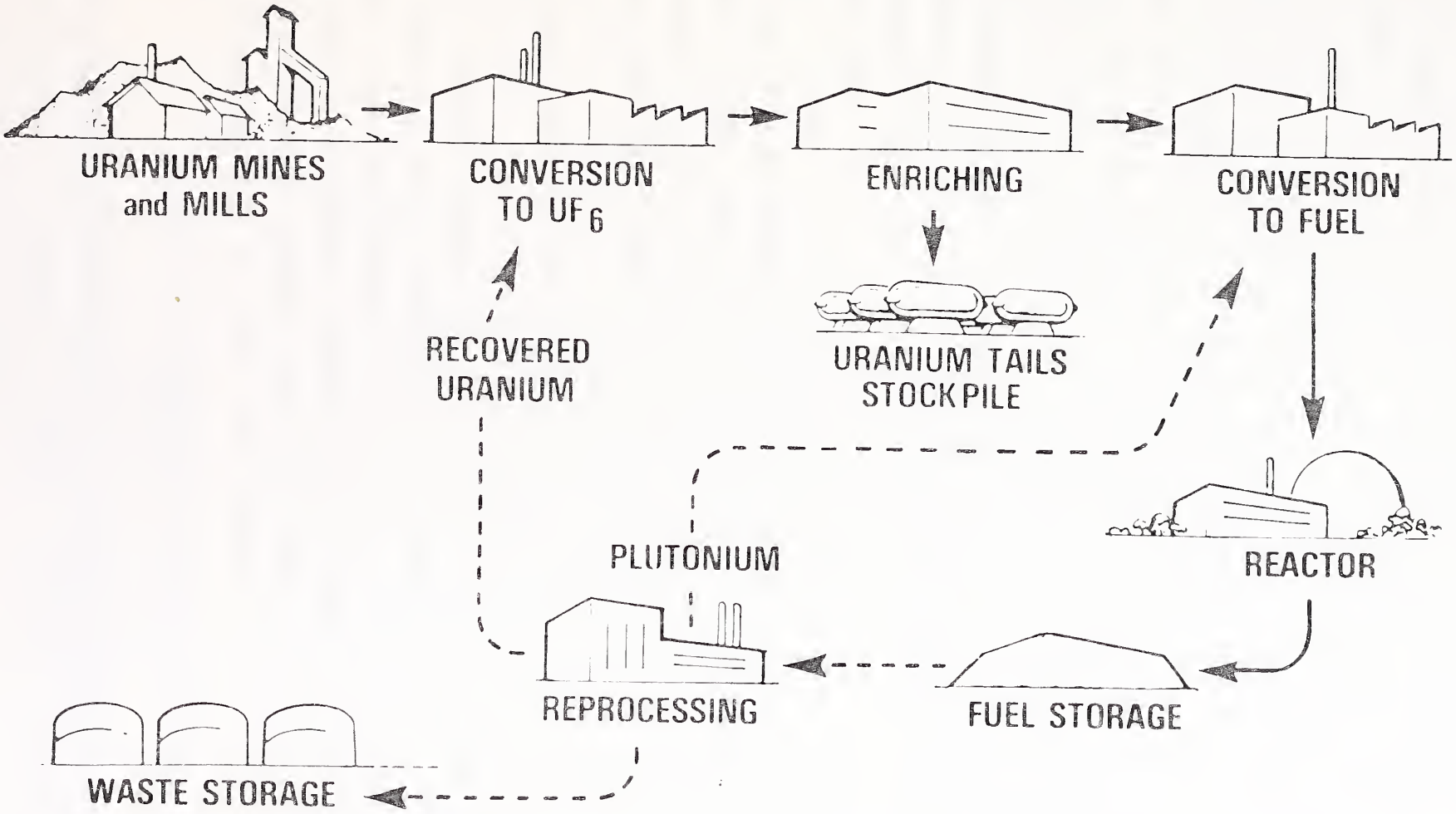


Figure I-1. The Light Water Reactor Nuclear Fuel Cycle.

again.

In its latest survey of uranium resources, the Energy Research and Development Administration has divided uranium deposits into two main categories: (1) reserves; and (2) resources. Ore reserve estimates are the most reliable figures because they are based on drill-hole and other geological data made available to ERDA by the uranium companies. Potential resource estimates are estimates of undefined and undiscovered resources in geologic formations in the United States, and these estimates are divided into three subcategories (probable, possible, and speculative) to reflect their degree of reliability. The reliability is greatest in the probable class where there has been extensive exploration and where mines have been developed -- thus defining local ore deposits. The reliability is least in the speculative class which is based on literature survey, geological reconnaissance of formation outcrops, and the examination of the logs and cuttings from wells drilled for petroleum and other purposes.

Because various grades of ore exist (average uranium ore from underground mines contained 0.22 and 0.20 percent $U_3O_8$ in 1974 and the first half of 1975 respectively) and because the ore occurs in deposits of varying thickness and scope and at varying depths, both resource and reserve estimates have been further categorized in terms of their "forward" costs of production. Forward costs are defined as those operating and capital costs yet to be incurred to produce a particular body of ore. They do not include profit and "sunk" costs such as past expenditures for property acquisition, exploration, and mine development. The various forward costs are independent of the market price at which the reserves and estimated resources would be sold. Table I-1 summarizes the latest estimates of uranium reserves and resources that could be recovered at various maximum forward costs. Each successive cost category includes the estimates of the lower cost category or categories.

Table I-1. Uranium Ore Reserves and Resources
(Thousand tons $U_3O_8$) *

| Forward Cost | Reserves | Resources | | | Total |
|---|---|---|---|---|---|
| | | Probable | Possible | Speculative | |
| $ 8/lb | 200 | 300 | 200 | 30 | 730 |

| Forward Cost | Reserves | Resources | | | Total |
|---|---|---|---|---|---|
| | | Probable | Possible | Speculative | |
| $10/lb | 315 | 460 | 390 | 110 | 1275 |
| $15/lb | 420 | 680 | 640 | 210 | 1950 |
| $30/lb | 600 | 1140 | 1340 | 410 | 3490 |

* U.S. Energy Research and Development Administration, Statistical Data of the Uranium Industry, Grand Junction, 1975.

In addition to the resources listed in Table I-1, $U_3O_8$ may be recovered as a by-product of phosphate and copper production. Also, the recent price increases for alternate fuels have opened the possibility of eventual utilization of uranium available at forward costs higher than $30/lb. The Chattanooga Shale in Tennessee has an uranium content of about 60 ppm and contains in excess of 5 million tons of $U_3O_8$ that would be producible perhaps at a forward cost of around $100/lb. This Chattanooga Shale, plus other low grade deposits, could yield as much as 26 million tons.

Presently known uranium reserves in the contiguous United States are concentrated in a few states. Major mining areas are found in Wyoming, Utah, Colorado, and New Mexico; in 1974, New Mexico and Wyoming produced 75 percent of all the $U_3O_8$ mined (see Table I-2).

Table I-2. Distribution of $U_3O_8$ Production In Ore by States, 1974. *

| State | Tons of Ore | Tons of $U_3O_8$ | Percent of $U_3O_8$ Produced |
|---|---|---|---|
| New Mexico | 2,997,000 | 5,400 | 43 |
| Wyoming | 2,458,000 | 4,000 | 32 |
| Colorado, Texas, Utah, Washington, and other states | 1,661,000 | 3,200 | 25 |
| Total | 7,116,000 | 12,600 | 100 |

* Source: Statistical Data of the Uranium Industry, ERDA GJO-100(75), January 1, 1975.

Excluding uranium resources potentially available from abroad, the

maximum nuclear capacity that can be supported based on presently available Light Water Reactor technology will be determined by the extent of our economically- and environmentally-producible domestic uranium resources. Assuming 70 percent capacity utilization, from 150 to 200 tons of $U_3O_8$ are needed each year to fuel a 1000 MW Light Water Reactor and two to three times that amount is needed to make up a complete initial reactor core. A total of approximately 6000 tons of $U_3O_8$ is required to fuel a Light Water Reactor for 30 years of operation.

The actual amount of $U_3O_8$ utilized will depend upon the operating characteristics and type of nuclear reactor, and two other important factors: the tails assay of the uranium enrichment plants and the recycling of uranium and plutonium from spent fuel. The 6000 ton figure assumes no recycling and a tails assay of 0.3 percent. By lowering the tails assay of the enrichment plant, more of the isotope U-235 is recovered from the feed stream, thereby lowering the requirement for $U_3O_8$. Lowering the tails assay to 0.2 percent would decrease uranium requirements by about 17 percent. Utilization of unburned uranium and plutonium from spent fuel discharged from reactors could also significantly decrease reactor uranium requirements by approximately the same percentage.

Given these assumptions, some 1.4 million tons of $U_3O_8$ will be needed to support the 240,000 MW of nuclear capacity currently in operation, under construction, or on order as of August, 1975, for their entire lives assuming 30 years of operation. As shown in Table I-1, the total of reserves and probable resources at $30/lb or less, which have been counted on for planning purposes, exceeds 1.7 million tons of $U_3O_8$, sufficient to fuel the 240,000 MW now on order or in operation and an additional 60,000 MW or more of capacity for 30 years of operation. Whether or not additional nuclear plants can be fueled beyond this 300,000 MW depends on how successful the industry is in the coming years in their uranium exploration efforts.

Continued exploration and development effort will be required to convert resources into reserves. Historically, there has not been a large incentive to explore new districts, especially since the uranium market has been quite soft. In fact, for many years the Federal Government encouraged development of the uranium industry, in order to meet military requirements, by guaranteeing to buy uranium at a fixed price. However,

conditions have recently changed uranium transactions into a sellers' market.

The uncertainties in the long-term availability of uranium have implications for the timing and planning of interrelated portions of the fuel cycle and for the need to develop new technology to replace it. To reduce uncertainty, the Energy Research and Development Administration has recently begun a large scale assessment of potential uranium sources in the continental United States and Alaska, which will not be finished for several years. These estimates will supplement existing information on undiscovered resources which are based almost entirely on data developed from previously productive geologic formations in the United States.

## Mining

In spite of the reduction of this year's (1975) estimates of nuclear capacity expected to be in commercial operation by 1985, $U_3O_8$ requirements will still have significant implications for the mining industry. In the last six years about 13,000 tons of $U_3O_9$ were produced annually in this country while existing milling capacity could handle as much as 17,000 tons. By 1985 two to three times (30,000-40,000 tons) the current annual amount of $U_3O_8$ will have to be produced and delivered for conversion and processing into fuels; this depends on the tails assay of the enrichment plants and whether plutonium and uranium are recycled. Milling capacity will have to be expanded to meet this level of annual demand. By the late 1970's, additions and modifications to existing uranium mills will increase industry capacity to about 23,000 tons annually.

As of January, 1975, a little over 100,000 tons of $U_3O_8$ had been committed for delivery by 1985. Uranium producers and utilities have made very few long-term delivery commitments for $U_3O_8$ in spite of the fact that a nuclear plant is expected to operate only for 30 years. Clearly, not all the annual requirements to fuel new and currently operating nuclear power plants has yet been contracted for. In fact, Westinghouse Electric Corporation contended that it was "legally excused" from honoring its contracts to deliver uranium to some customers after 1978 for the contracted price. This action could affect the delivery of up to 40,000 tons of $U_3O_8$ over a period of years for which utilities had contracts with Westinghouse.

Numerous market uncertainties have dominated the industry's thinking

about future investment in uranium mining. Today the industry faces a number of market uncertainties as a result of delays in nuclear capacity additions, the incremental lifting of the ban on imports of uranium for domestic use beginning in 1977, the lack of a final decision on the plutonium recycle question, and the potential of possible local nuclear moratoria.

Uranium prices will probably serve as an incentive to continue exploration and development of domestic uranium resources. The average price for material delivered in 1974 is reported to have been $7.90/lb. Projected prices under new contracts have increased sharply. Because material for near-term deliveries was largely under contract, the most significant impact of the higher prices in terms of cash flow and financial ability to continue exploration for new uranium deposits will occur in the late 1970's and early 1980's.

It is estimated that it takes about seven to eight years from exploration drilling to production mining and that it takes three years to open a mine and two years to construct a mill. Adequate incentives could probably reduce the time schedules for machinery and equipment. Capital costs for needed uranium mining and milling activities could be on the order of several billion dollars in the 1975 to 1990 period; however, the major portion of the capital will be required after 1982 or 1983.

## Long-Term Storage of Radioactive Waste

ERDA is responsible for the long-term management of commercial high-level radioactive waste and for other commercial waste which might be identified by Federal regulations as requiring Federal custody. ERDA requirements on waste handling obligate the commercial processor to convert the high-level waste solution to a stable solid (the precise composition of which is still unspecified) and to seal the solid material in high-integrity canisters of manageable size before transferring the material to a Federal repository. This requirement assumes that spent fuel will actually be reprocessed. In view of the present uncertainty on the processing issue, the question of the management of commercial waste and its ultimate storage is not completely resolved. If reprocessing does not occur, the spent-fuel rods themselves will have to be stored rather than storage of some solidified form of the aqueous wastes resulting from the chemical process necessary to separate uranium and plutonium from the

spent fuel.

Permanent underground storage in a stable geologic zone is considered to be the most attractive final means of storage to take care of high-level radioactive waste. The search for such acceptable sites is continuing, and once an underground location is chosen, tests will be conducted to determine if the means and location of storage is environmentally acceptable.

Clearly, long-term waste storage remains a significant issue in nuclear development. With the slippage in nuclear capacity additions and the delay in the decision to permit mixed oxide fuel use, the pressure for an immediate resolution of the storage question has been slightly alleviated but remains an urgent problem. Technical and practical problems as to the best method of terminal storage must be resolved to assure that high-level waste generated in the future can be taken care of and to reduce the criticism and apprehension created by uncertainties about this end of the fuel cycle.

## Summary

The development of the nuclear fuel-cycle industry is essential to the expansion of nuclear power. A number of technical and other issues related to the fuel cycle remain unresolved. These issues must be addressed soon, and satisfactorily resolved so that they do not become obstacles to further nuclear development. This is particularly true for the so-called "back-end" of the fuel cycle.

Nuclear-reactor-generated electricity contributes to United States energy independence only to the extent that there are abundant domestic reserves and resources of uranium ore which is the basic input into nuclear fuel. While there is some uncertainty as to the size of the uranium resource base for the long term, ERDA has an extensive program (NURE) underway to locate the new uranium resources which will be needed if the use of Light Water Reactors is to continue nuclear expansion to the turn of the century and beyond. In the near term, reserves are sufficient and domestic uranium producers must expand and develop new mines and milling capacity to meet future uranium requirements. Timely investment in additional mining and milling capacity has been hampered by uncertainties about future demand,ore prices, and a shortage of capital. Resolution of regulatory uncertainties, different contracting arrangements between

producers and users of uranium, and greater certainty about future requirements should lead to the needed investment in exploration and facilities.

Current government-owned enrichment facilities can support about 315,000 MW, assuming fuel reprocessing and plutonium recycle. Fixed contracts for 208,000 MW domestic and 107,000 MW foreign have been signed by ERDA. In order to permit orderly development of the LWR industry regardless of whether or not plutonium recycle is permitted, and to preserve the market position of the United States in world nuclear development, additional new enrichment capacity will be needed in the mid-1980's. Current plans are to meet this need through private sector construction of a new nine million SWU gaseous diffusion plant to be on line in the mid-1980's and with increments of three million SWU centrifuge plants as required by projected demands for later years.

Spent fuel reprocessing is dependent upon: (1) a favorable ruling from the Nuclear Regulatory Commission on the wide scale use of plutonium for fuel; (2) the decision by utilities that it is economic to recover just the uranium from spent fuel in the event that plutonium use in LWR's is prohibited; and, (3) the resolution of a number of technical issues associated with reprocessing and fuel fabrication. Until these questions are resolved, the industry cannot plan with confidence. It was estimated that the earliest that spent fuel reprocessing could begin was in 1977. There have been delays beyond this date such that nuclear power plants have had to expand their spent-fuel storage pools to accommodate several years of spent fuel discharges. Most spent-fuel storage pools appear to be capable of significant expansion.

Because of slippages in nuclear power plant and spent fuel reprocessing schedules, the onset of high volumes of radioactive waste has been postponed a few years. This should give the Nuclear Regulatory Commission and ERDA time to develop acceptable standards for the delivery of aqueous wastes in solidified form and to choose appropriate geologic locations for terminal storage. This does not postpone the urgent need to resolve these problems to assure the public that adequate provisions have been made for terminal radioactive waste storage.

If plutonium recycle in Light Water Reactors is not permitted and if utilities decide to have their fuel reprocessed to recover just uran-

ium from spent fuel, then provisions will have to be made to store both high-level wastes and plutonium for possible later use in breeder reactors. If neither recycle nor reprocessing take place, then terminal storage plans will have to be made for spent fuel rods.

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